THE

JOURNAL OF GEOLOGY

NOVEMBER-DECEMBER, 1895.

THE GREENLAND EXPEDITION OF 1895.

AFTER an unfortunate delay, the Greenland expedition of 1895, which was to bring Lieutenant Peary back to America, left St. Johns on July 11 in the steamship *Kite*. Instead of heading for Cape Desolation, a more northerly route was chosen, which, had it been held, would have brought us to the coast of Greenland in the vicinity of Frederickshaab. The first stop was to have been at the Frederickshaab glacier, but as the land was approached the fog was so dense and so persistent that it was deemed inadvisable to attempt a landing, and the coast was first seen at a point somewhat further north, in latitude 64° 30′ as nearly as was determined. This was on July 17.

Coastal topography and its interpretation.—The first glimpse of the coast was hardly more than momentary, but it was quite sufficient to reveal the essential features of the coastal topography. Fog shrouded and effectually concealed the lower half of the bold land front, but the upper half consisted of a succession of distinctly serrate peaks, many of them with slopes so steep that it would have been difficult or impossible to scale them. The serration was so pronounced as to be most significant, and seemed clearly to substantiate the general conclusion at which Professor Chamberlin arrived last year, namely, that there were portions of the Greenland coast which have not been glaciated in recent time.

The stretch of coast seen in this latitude was no more than ten or fifteen miles in extent. North of this point the coast was

completely concealed by fog for some miles. When it again appeared, in latitude 65°, as nearly as was determined in passing, it presented a very different aspect. As before, the lower portion of the land, perhaps the lowermost 500 feet, was not seen. The contours of the southernmost portion of this stretch were in striking contrast with those of the region but a few miles further south. Instead of being markedly serrate, the topography was thoroughly subdued, and suggested as strongly as topography can suggest, that the surface had been heavily and recently glaciated. But this was true of the southernmost portion only. In latitude 65° 20′, as nearly as was determined, there was a sudden change in the appearance of the coast. North of this parallel, and extending thence to latitude about 66° 45′ or thereabouts, there succeeded a stretch of territory with serrate front similar to that which characterized the region in latitude 64° 30′. At 66° 45′, or thereabouts, this second stretch of serrate topography gave place to a topography of smooth and flowing contours, indicative of recent glaciation, and corresponding, in all essential features with the topography of the coast just above the 65th parallel. From this point to latitude 69° the coast was seen at intervals only; but wherever seen, it presented the contours which denote vigorous ice-action. The same sort of topography characterizes the coast continuously from latitude 69° to latitude 70°, as was seen in our further progress, so that with the possible exception of short stretches not seen, glaciation would seem to have been continuous along the coast from 66° 45′ to 70.

North of this latitude, the coastal topography, while not so markedly serrated as that at 64° 30′, or between 65° 20′ and 66° 45′, was still of such a character as to suggest that if it had been glaciated at all in recent times, the glaciation was not severe. On the whole, judging from topography alone, it seemed more probable that the coast from about latitude 70° north to the end of the Nugsuak peninsula, had not been recently smothered in ice, though it is well possible that the ice-cap may have once extended beyond its present limits, and that isolated glaciers

occupied the valleys leading down to the sea. The northwest end of the peninsula bears the marks of the passage of ice over a considerable part of the coastal front. North of Nugsuak peninsula, and from that point to the south side of Melville Bay, the topography of the coast, so far as seen, indicated general though not universal glaciation. Thus the southwestern end of Svarten Huk peninsula (71° 30′) has a topography denoting the absence of glaciation.

North of the Nugsuak peninsula it was often difficult to distinguish between the topography of the mainland and that of the islands. Ubekyendt Island (lat. 71° 15′), or at any rate much of its west front, has a serrate skyline. North of 72° 30′ also, the topography is not such as to denote continuous glaciation over the outlying islands, even if the mainland was covered down to the water level. It would appear that the comparative phenomena of islands and mainland north and south do not agree—for south of latitude 70° the islands lying near the coast correspond in topography with the mainland opposite.

Except for thirty miles or so east of Cape York, the coast of Melville Bay was not seen. Along that part of the coast which was seen, the ice reaches the sea so generally, that something like three-fourths of the coast line is composed of it. This ice is not the edge of the ice-cap, strictly speaking, but consists rather of a succession of broad glaciers separated from each other by short distances only. In spite of the iciness of the coast it is doubtful if all its islands, even but a few miles from the coast, were ever overtopped by glacier ice.

North of Cape York, the ice-cap is nowhere distant from the coastal margin of the upland; yet there are many considerable stretches where there is no evidence, either in the topography or in the surface formations, that the ice ever reached the sea as a continuous sheet. In many places there is evidence that the edge of the ice-cap approached the coast more closely than now, in relatively recent times, and that its excess of material was discharged in the form of glaciers, some of which occupied valleys now free from them. But even where the ice has been recently extended, there

is evidence of no more than a very moderate increase beyond its present limits, and between the valley glaciers which existed at the time of the greatest extension of which there is record, there often remained peaks or even considerable areas altogether free from moving ice. But there are other areas where the surface affords no evidence that the ice-cap was ever extended much beyond its present limit. Professor Chamberlin has called attention to the existence of a small driftless area[1] on the east side of Bowdoin Bay, reaching almost to the edge of the present ice-cap, basing his determination, not on topography alone, but on the absence of drift, and on the presence of a great body of earthy matter resulting from the decomposition of the underlying rock.

The conclusions reached by Professor Chamberlin last year during his voyage in the *Falcon*, viz: (1) that there are considerable stretches of the west coast of Greenland which have never been glaciated, or at any rate not glaciated within any time so recent as the later epochs of our own glacial period; and (2) that the ice-cap of Greenland—in the vicinity of Inglefield Gulf—was never greatly more extended than at present, or at least that it has not been notably extended within recent times, seem to me to be the only conclusions to which such study as is possible in such a voyage can lead.

This condition of things on the Greenland coast is not without its parallel on the east coast of America (Ellsmere Land, North Devon, Baffin Land, etc.). This coast was seen at intervals from latitude 78° 45′ to latitude 71° 30′. Within this distance there are places where the topography is such as to suggest that the coast has not been glaciated or at least not in recent times. This is true, for example, of some parts of Bylot Island, latitude 73°, and perhaps more conspicuously of a considerable stretch of the mainland coast in the vicinity of Dexterity Harbor, the latitude of which was not exactly determined, but which is not far from 72°. It cannot be asserted, on the basis of present evidence, that there are extensive areas in either of these positions which have altogether escaped the ice,

[1] Bulletin of the Geological Society of America, Vol. VI, p. 818.

but if reliance may be placed on topographic form, it seems clear that in both these places there are considerable stretches of coast over which no ice, except perhaps isolated glaciers, has descended in any recent time. This is the more noteworthy from the fact that the same regions now harbor very considerable glaciers, while the ice-caps which feed them approach very close to the outer edge of the upland. Fully a dozen glaciers, and the ice-cap above which nourishes them, were visible on the northeast side of Bylot Island, while about Dexterity Harbor there are very considerable glaciers, some of them descending nearly to the water level, separated from each other by serrate peaks which do not appear ever to have been over-ridden by ice, though the ice-cap today is no more than two or three miles distant.

In view of the facts already mentioned concerning the topography of the Greenland coast, it seems to be impossible to avoid the conclusion[1] that the Pleistocene ice-sheet of our continent did not have its starting point in Greenland. If reliance may be placed upon coastal topography, the phenomena observed on the American coast would seem to indicate further, that the great center of ice accumulation during the Pleistocene period was not on the most northerly lands on the west side of Baffin Bay. Had this been the case, Bylot Island, and the coast of the mainland in the vicinity of Dexterity Harbor, would hardly have escaped glaciation at the same time that the Labrador coast and its outlying islands were subjected to the action of ice on an extensive scale; and had latitude (at least present latitude) been the determining factor in glaciation, the west coast of Greenland north of latitude 76° would hardly have suffered so slight an extension of its ice as its condition seems to indicate, while more southerly regions were less favored.

It is to be borne in mind that the foregoing conclusion concerning the meager extension of ice-caps of the west coast of North Greenland and the east coast of America, in recent time, is based on general, rather than on detailed observation, and that

[1] Chamberlin, loc. cit., p. 219.

it is possible that the importance of topography in its bearing on this question, has been overrated. But if the conclusion be correct, it will be seen that it is not without bearing on the question of the cause of the glacial period. Of related import is the fact that the conditions for glaciation on the Greenland coast seem to be much better today in latitude 74° to 76°, than in latitude 76° to 79°. It is not merely that there are more and larger glaciers in the former region, descending to lower levels — for all this might be the result of topography — but the snow line itself is 1000 to 1200 feet lower in latitude 76° than in latitude 78°.

Evidence concerning past glaciations, drawn from nature of rock surfaces.—The first stop on the coast of Greenland was at Holstensborg, latitude 67°. The rock in this region is gneiss, which is much more distinctly and regularly bedded than gneissic formations usually are. From a distance, the rock has the appearance of being distinctly stratified, the dip being tolerably constant. So strong was this impression that it was difficult at a distance to avoid the conclusion that the rock was sedimentary. The general dip is to the northward, at an angle of 60° to 75°. On the land, the gneiss is seen to be affected to some extent by dikes of granite, but they are not sufficiently numerous to obscure the general regularity of structure. Its surface has undergone a notable degree of decomposition since glaciation. Striæ were not seen, nor did the rock surface show the polishing which glacial action produces. All these details were gone, although hills having the form of *roches moutonnées* were of common occurrence, and glacial drift was not wanting. This condition of things suggested that the lapse of time since the departure of the ice has been considerable. This is the more significant since it is in striking contrast with the condition of things along some other parts of the coast. It is clear that the cursory examination of the surface of a small area does not afford a safe basis for generalization. Nevertheless it is worthy of note that the amount of change undergone by the surface of the gneiss about Holstensborg since the ice abandoned it, appears to be greater than the average amount undergone by similar forma-

tions in the United States, since the departure of the last ice sheet.

The amount of drift in the vicinity of Holstensborg is slight. From the vessel it appeared as if the larger part of the surface was bare rock, but on the land the proportion of the surface covered by loose material was seen to be somewhat greater. The topography about Holstensborg is such as to suggest that the ice was never very effective in reducing it. It seemed to me probable that some of the higher peaks were nunataks at the time of maximum ice extension, while others of intermediate height were not covered by a great thickness of ice, and did not suffer any considerable modification of form.

The next stop on the coast of the mainland was at Jakobshavn, about 120 miles further north. Here as at Holstensborg, the rock is gneiss, though much less distinctly and regularly bedded. Occasionally it is closely foliated, and the foliations are locally much contorted.

The little peninsula lying north of Jakobshavn was crossed along two lines, and its general features well seen. Its surface everywhere bears the marks of glaciation, and the action of the ice here seems to have been much more intense—so far as topography affords a basis for judgment. Rarely is there better opportunity for observing the topographic effects of glaciation. The relief of the region is about 1400 feet. The surface before glaciation seems to have been affected by an erosion topography, in the early maturity stage of development. In its general westerly movement, the ice smoothed the eastern sides of the hills and ridges, at the same time that it plucked their western sides. The structure of the rock is such as to favor both processes, with ice moving in the direction which it here took, and both processes were therefore carried to an unusual degree. The result was that, standing in almost any valley and looking westward, smooth and relatively even slopes were seen, so characteristic as to leave no doubt as to the agency which produced them, or the intensity of its action, while looking in the opposite direction bold, rough walls of rock, with huge piles of angular bowlders

at their bases, greeted the view. Rarely is the contrast between the lee and stoss sides of hills so clearly marked.

Apart from its topography, the surface of the rock near Jakobshavn was found to be in striking contrast with that at Holstensborg. Instead of being decayed, it was remarkable for its freshness, especially at elevations of a few hundred feet and a few miles inland. For the first few miles from the coast striæ were often seen, but they were also often wanting. Four or five miles inland, and from that point eastward to the limit of the land seen, it was the exception not to find the rock polished, and still retaining the grooves and fine lines due to the graving of the ice in all their pristine freshness, even where its surface has been continuously exposed since the departure of the ice. The surface was such as to give the impression that it had but just been freed from the ice which had polished it.

The bareness of the rock was one of the most striking characteristics of the peninsular surface. It is probably safe to say that half the surface seen in a jaunt of fifty miles is absolutely without soil or loose material of any sort whatsoever; that half of the remainder has a mantle of loose material, averaging less than two feet in depth ; while the remaining fourth has sufficient drift to effectually conceal the rock.

The contrast presented by the rock at Holstensborg and Jakobshavn, both in the matter of topography and freshness of surface, was repeated at other points further north, seeming to indicate that the glaciated surfaces now free from ice along the west shore of Greenland have been free for very unequal periods of time. In some places the surface seems to have been but just abandoned, while in other cases, even where the evidence of severe glaciation is equally conclusive, the surface seems to have been exposed to the influence of weathering for a much longer period of time. This leads to the conclusion that the ice-cap of Greenland did not suffer its greatest extension at all points at the same time. It is quite harmonious with the theory, though in itself does not prove it, that there have been distinct epochs of ice extension (perhaps distinct glacial epochs) during which the

ice-cap moved forward unequally, advancing farther from its present position at one point in one epoch, and at another point in another. Opportunity was wanting to carry observations sufficiently far to place this suggestion on a firm basis of fact.

General disposition of snow and ice. Nowhere on the west coast of Greenland between the latitude where land was first sighted (64° 27′) and 69° was the main ice-cap seen from the Kite, along a course five to fifteen miles off shore. At a few points only, what appeared to be local ice-caps or local snow fields came into view. In one or two places between 66° and 67° there depended from these local snow fields what appeared in the distance to be incipient glaciers. In other places local snow fields were seen of such size that they can hardly fail to give rise to small glaciers, though from our position they were not seen.

At many points along this coast, as seen in July, there were considerable patches of snow, generally occupying ravines, which seemed to be the unmelted remnants of considerable drifts. These occurred at all altitudes, even down to the level of the sea. Many of the patches of snow were of such size and thickness that it was quite certain that they would hold over until the succeeding winter. They were in all cases apparently due to excessive local accumulation by the wind, and do not in any way indicate the altitude of the snowline in these latitudes. The height of the snow line was not determined here, but it is probably not less than 2000 feet, and may be somewhat higher.

North of latitude 68° 30′ the ice-cap appears to approach the coast much more closely than farther south, but even here its edge is so distant and so related to ice-free lands (often islands) in front of it, as not to be generally seen from the open sea. From a point a few miles back of Jakobshavn (lat. 69°), the glacier which bears that name, and the ice-cap beyond, were distinctly seen. Between latitudes 69° and 70° the main ice-cap to the east was now and then seen, either at the head of fjords, or where the coastal topography permitted an unusually unobstructed view to the eastward. North of Prince Island, the end

of the glacier entering the head of Torsukatak fjord was seen—as well as the ice-cap behind it. Further north, during the passage of the Waigat, the local ice-cap of the Nugsuak peninsula was now and then sighted, though it sends no glaciers of importance to the southwest.

With the west coast of the Nugsuak peninsula the east coast of Disco is in striking contrast. On the latter the ice-cap very commonly reaches the edge of the upland, and nourishes numerous small glaciers which descend the slope some hundreds of feet.

Between the north end of the Nugsuak peninsula (lat. 70° 45′) and 74° 30′ the main ice-cap was rarely, if ever, seen. If the published charts be correct, this must have been due to the very considerable number of ice-free islands which lie off the coast, and hide the front of the mainland. That the ice-cap or at least huge glaciers from it reach the coast in very considerable numbers in this region, is demonstrated by the fact that large numbers of bergs take their origin from the coast in these latitudes. The local ice-cap of the Svartenhuk peninsula (lat. 71° 30′) was seen at several points.

The glaciers seen on Disco Island, and on the west coast of Greenland south of Melville Bay, do not depart from the usual type of alpine glacier, so far as general form and relations are concerned. Some of them—as the Jakobshavn glacier—are much larger than the usual alpine type, but they lack the peculiar characteristics which seem to mark the glaciers of the higher latitudes of west Greenland.

The north shore of Melville Bay was not seen except for twenty-five or thirty miles east of Cape York, where the coast line is very largely made up of ice. This ice is mainly in the form of glaciers—as distinct from ice-cap—but they are wide, often confluent, and, where distinct, are frequently separated by no more than trivial areas of land.

It was characteristic of all the glaciers seen along Melville Bay that their gradients were low; that their surfaces were relatively smooth and free from débris; that their centers were

but slightly higher than their sides, that is, that they were but slightly arched in the cross-section; that their vertical fronts were very slight; and that their lateral margins rarely presented vertical sections.

One or two peculiar phenomena of this region merit special mention. In two of the minor indentations on the coast of Melville Bay, the ends of glaciers were seen to be floating. These little bays had not freed themselves from the ice of the preceding winter,—probably not from the ice of many preceding winters. The topographic relations are such as to indicate that the water deepens from the head of the bay outward, and from the lateral margins inward, very gradually. In their advance, the glaciers entering these bays at their heads encounter the bay ice, crowd it, break it more or less, and heap it up in front of themselves. But in the cases referred to, they had not forced it out, and it still constituted a barrier to their advance. The result was that the ends of the glacier were not broken off, or at least not floated away in the form of bergs, as would have been the case in open water. Since the water was shallower near the margins of the bay and deeper in the middle, the lateral margins of the protruding glacier continued to rest on the bottom, while its central portion got beyond its depth and was floated. The deepening of the water from the margins of the bay toward the center appeared to be so gradual, that in neither of the two cases seen did the floating center of the glacier appear to be greatly fractured where it joined the marginal portion which was still resting on the bottom. Similarly the deepening of the waters from the head of the bay out was so gradual that the floating portion of the end was not separated by any notable fault from the ice above which still rested on the bottom. That the central portion was actually floating, however, was shown by the approximate flatness of its surface, by the fact that it was somewhat lower than the marginal parts, in one case as much as thirty feet lower, and by the occasional gaping fissures which exposed the salt water beneath. In both cases the lateral margins of these glaciers, the central portions of

which were floating, carried lateral moraines containing shells worked up from the bay bottom. In one case they were fully thirty feet above sea level. Phenomena of similar import, so far as glacier motion is concerned, were seen at many points, but never in any position except at the immediate edges or ends of glaciers.

In the same general locality there was another interesting phenomenon on some of the islands, and occasionally on the coast of the mainland. Even where the summits of islands were wholly free from snow, several places were seen where their lower slopes had perennial ice-caps reaching down to the water, and even appearing to be thickest at that level. This appeared to be the result primarily of the excessive local accumulation of snow, under the influence of the wind. Lodging against lee slopes, it had reached such thicknesses as to defy the sun. In several places, some of them on islands and some of them on the mainland, the accumulation had gone so far as to give rise to glaciers. That the ice was actually in motion was evinced by its structure, and by the débris which it carried.

Under these circumstances, it was difficult at many points to determine the altitude of the snow line, but on the narrow promontory just back of Cape York a satisfactory determination was made, giving the snow line an elevation of about 1000 feet (aneroid measurement). The ice-cap yielding this result is an isolated one, having an area of no more than five or six square miles. It would seem that the lowness of the snow line here must be the result of local meteorological conditions. There can be little doubt that the snowfall at Cape York is exceedingly heavy, since the small ice-cap referred to has a glacial discharge altogether out of keeping with its area. It feeds two active glaciers, one of which is considerably more than a mile in width, and both of which descend to the level of the sea, discharging small bergs.

North of Melville Bay the snow line is much higher. In the vicinity of Inglefield Gulf it averages fully 2000 feet, and in many places it rises as high as 2200 or 2300 feet. Accompany-

ing the rise in the snow line, though the association may be no more than accidental, the glaciers take on a somewhat different aspect. In general they are narrower, thicker, more arched in cross section, more extensively fractured, and, most striking of all, have, as a rule, vertical sides and ends. Furthermore, their surfaces are much more likely to carry débris along their lateral margins and across their ends, wherever the ends are not more than 150 feet or so thick. These features characterize most of the glaciers seen on the Greenland coast north of latitude 76°. It is true that there are occasional glaciers within this distance which fail to show these characteristics, but they are so rare as to be conspicuous. Thus on the south side of Whale Sound there is a single glacier which has neither vertical sides nor end, although these features are possessed by all the other ice streams on this shore of the Sound. An adequate explanation of this very striking difference in the behavior of the Greenland glaciers north of Cape York and those east and south of that point has not yet been suggested. Such opportunity as was afforded for the detailed study of glaciers was principally within the region where vertical slopes abound.

North of Cape York there is a type of glacier so common as to deserve especial mention. On its seaward margin the upland often terminates abruptly, and from its edge a steep slope descends to the water. The uppermost part of this cliff face, just below the outer edge of the upland is often nearly vertical for a short distance. The junction of the vertical, or nearly vertical, face with the less steep talus slope below, is often the site of great accumulations of snow, drifted thither by the wind blowing from the plateau. These accumulations are not usually continuous for any considerable distance horizontally, but rather are gathered in patches wherever the topography favors lodgment. The patches of snow in these situations have in many cases become so considerable as to give rise to little glaciers. They do not usually descend more than a hundred feet below the snow fields which support them, but their glacier character is unmistakable.

This type of glacier seem to deserve a special name. Since both they and their feeding grounds are on the faces of cliffs, it is proposed to designate them *cliff glaciers*. It sometimes happens that the snow fields which support these tiny glaciers

FIG. 1. A cliff glacier on the north side of Herbert Island, a northerly dependence of Murchison Sound. The upper part of the glacier is covered by snow, which also borders it and fills the ravine below. The lack of connection with the ice-cap is shown by the line of rock out-crop above the glacier, the ice-cap lying some distance back.

coalesce laterally along their upper edges. Cliff glaciers were seen at other points, but nowhere else so strikingly developed as north of Cape York. Especially good examples are seen on the north side of Herbert Island and on the east side of McCormick Bay. These glaciers are really one in origin with the low lying glaciers already referred to as originating in huge drifts of snow banked against the lower slopes of islands

and mainland east of Cape York, but they take on a distinctly different form, and the glaciers are much better defined.

The coast west of Baffin Bay has, where seen, a much more wintry aspect than the coast of Greenland in correspond-

FIG. 2. A series of cliff glaciers on the northeast side of McCormick Bay. The line of rock out-crop at the upper limits of the glaciers is but indistinctly shown in the figure, but is suggested by the dark line.

ing latitudes, Melville Bay alone expected. Where the coast is low, the ice-cap descends to lower levels on the American side of the water than on the Greenland side, leaving a narrower margin of land free from ice. This is in harmony with the fact already noted that the ice-cap comes nearer the coast on the east side of the Island of Disco than on the west side of Nugsuak peninsula opposite. It is also in harmony with the further

fact that the ice-cap of Disco approaches its eastern shore much more closely than its western. In other words the generalization seems to be warranted that the ice is better developed along the eastern borders of land, than along the western.

Not only is the snow line lower on the east coast of America than on the west coast of Greenland, Melville Bay excepted, but the glaciers of the regions present certain contrasts. In and about latitude 78°, the glaciers of the Ellesmere coast were seen at a distance only, but they seemed to possess the general characteristics of those east of Cape York, rather than those of the Greenland coast further north. So far as seen, they are relatively broad, flat and clean, without notable vertical sides and without vertical ends except where they reach the sea. It is not to be understood that this is true of every glacier within the region specified, but it seemed to be the rule rather than the exception. It is to be noted that this is the latitude in which the glaciers opposite, on the coast of Greenland, are notable for their abrupt sides and ends. It is to be noted also that these are the characteristics of the glaciers east of Melville Bay, where the general aspect of the coast, so far as concerns snow and ice, is very similar to that of the American coast.

Similar characteristics mark many of the glaciers about Jones Sound, especially on the south side. Further south, the ends and margins of the glaciers are less abrupt than on the Greenland coast north of Cape York, but distinctly more so than east of Cape York, on the north coast of Melville Bay. In latitude 71° to 73°, there are many glaciers which have vertical sides and ends such as characterize the glaciers of the higher latitudes on the Greenland coast. It is clear, therefore, that the vertical faces of the glaciers are not the result of high latitudes simply. Whatever may prove to be their explanation, it seems to be true that thick glaciers of high gradients are much more likely to possess vertical sides and ends, than thin glaciers of low gradients.

Bergs.—Soon after leaving the harbor of St. Johns occasional icebergs began to show themselves. These proved to be of

somewhat common occurrence, for at the end of the third day thirty-six had been sighted. Since the atmosphere was almost continuously clear, this number may be taken to represent essentially all that were within range of vision from the vessel during the hours of daylight. Although our course was continually bringing us nearer the source of the bergs, only two were seen on the fourth, fifth and sixth days. Their scarcity in this latitude (55° to 62°) was taken to mean that we had passed the eastern limit of the Arctic current, which was bearing them southward. As the coast of Greenland was approached they became again somewhat more common, and by the time Holstensborg was reached not less than 125 had been sighted.

As the coast of Disco was approached from the south, bergs became much more abundant. From the time the coast was sighted until the harbor of Godhavn was reached there was rarely, if ever, a time when as many as fifty could not be seen. Seventy-five were counted in the immediate vicinity of the harbor, and from the land above the settlement, a few hours later, 160 were seen in the little bay to the northeast.

Most of the bergs seen to this point were relatively small, the largest being perhaps not more than 100 feet in height and 200 to 400 feet in length. In most cases they showed that they had been long afloat, and that they had been subjected to considerable changes of position since the beginning of their history, for incisions made by the waves girdled them at all angles. In some cases they were affected by caves and archways, often of remarkable regularity; in other cases their tops were marked by high pinnacles and towers, sometimes having a regularity approaching that of an elaborate architectural design. Without exception they were altogether free from débris, and their colors were the colors of pure ice, varying from white to blue on the one hand, and from white to green on the other. A more perfect or more beautiful gradation of colors could hardly be imagined. More massive bergs were seen at other points, but none more beautiful.

East of Godhavn bergs were abundant continuously to Jakobs-

havn. During the voyage between these points, a distance of about sixty miles, there was hardly a time when less than 100 were in sight, and it is probably quite within the limits of truth to say that 500 were seen between these settlements. So abundant were they that from many points the half of the horizon was concealed by them.

In the Jacobshavn fjord, the upper part of which at the time of our visit (July 23) had not freed itself from the winter's ice,[1] bergs were literally packed. In the outer part of the fjord they were free to move, and were sailing in and out, under the influence of wind and current. But further up the fjord they were imprisoned in the surface ice in such numbers as to suggest that the fjord had not been freed from ice for several years, and that the entire discharge of the huge glacier at the head of the fjord for those years was still fast in the ice.

The bergs in the fjord and near it presented two very distinct types: (1) Those whose surfaces were notably irregular, often a series of ice needles, and (2) those whose surfaces were relatively smooth. The surfaces of the former corresponded with the surface of the glacier above. They were the bergs which had moved out in upright positions. The bergs with smooth surfaces, on the other hand, were those which had capsized at some stage or other of their history, and since they were still imprisoned in the fjord ice, the turning doubtless took place when the bergs separated from the glacier.

The difference in the shape of the upper surfaces was uniformly accompanied by another significant difference. Those with smooth surfaces were always clean, while the upper surfaces of those with irregular tops were always discolored by a thin, discontinuous layer of mud. In this, as well as in their form, the surfaces of the irregular-topped bergs corresponded exactly with the surface of the glacier which gave them birth. It was here apparent that the bergs with clean upper surfaces had shifted their positions in the course of their history, while

[1] Governor Müller, of Jakobshavn, is authority for the statement that the fjord is not usually freed from ice oftener than once in four or five years.

those with dirty surfaces were still right side up. The conclusion that bergs with clean surfaces have been tilted or capsized in the course of their history was first reached at Jakobshavn, but it proved to be of general application. The ends of all glaciers seen had their surfaces covered with a sufficient amount of débris, mainly wind-blown dust, to give them a distinctly grayish appearance. In consequence, every berg originating from them, if it set sail without capsizing, must have a discolored surface. That many bergs do begin their history right side up — that is, with the parent glacier surface up — is shown by the fact that in the immediate vicinity of the calving glaciers the upper surfaces of many of the bergs are discolored.

In no case did the vertical faces or upper surfaces of the bergs about Jacobshavn show bowlders or detritus of any sort. This was in perfect harmony with the phenomena exhibited by the end of the glacier which had given origin to them, for neither its vertical front nor its upper surface showed a single stone, large or small, nor any trace of finer material. This in itself seems to be sufficient proof that the small amount of fine débris upon the upper surface had reached its position at the hands of the wind.

The bergs calved by the Jakobshavn glacier were 100 to 200 feet above water, and the vertical end-face of the glacier was of corresponding height. It is clear, therefore, that the thickness of the glacier at its end is very great. That its lower layers, and consequently the bottoms of the bergs at the beginning of their history were charged with débris, can hardly be doubted.

Above Jakobshavn, bergs continued to be plentiful through the north part of Disco Bay, though perhaps less abundant than opposite the Jakobshavn fjord. To the south entrance of the Waigat there was rarely a position where as many as fifty might not be sighted, and their average size was greater than at any point further south. While they did not often exceed eighty or one hundred feet in height, they were often 1000 feet or so in horizontal extent. Here for the first time occasional bergs were seen in which certain well-defined layers of ice, containing

more or less earthy débris, stood out distinctly between the layers of cleaner ice on either hand. This was seen only in bergs which had been tilted, so that the originally horizontal layers had become highly inclined. The débris-laden layers were apparently layers which were near the bottom of the parent glacier and near the bottom of the berg at the beginning of its history.

A considerable procession of bergs was seen coming out of the fjord north of Prince Island, some of them being very massive. In this region an occasional berg was seen so completely covered with débris as to be essentially black. Such bergs were all very low, none of them being more than ten or fifteen feet in height. As subsequent observations indicated, they must have come from glaciers, the ends of which, as they reached the sea, were very thin; that is, glaciers, the upper surfaces of which were very near the lower. They therefore do not violate the general rule that the débris of the glaciers is not far above their bases. Glaciers with thin ends and edges, and such only, have abundant débris, apart from occasional medial moraines, on their upper surfaces.

In the Waigat, and for a considerable distance north of it, the bergs were, on the whole, considerably flatter than those further south, rarely standing more than fifty feet out of water. From thirty to fifty were generally in sight until the entrance to Umanak fjord was approached. Here a noble fleet of them, more than 100 by actual count, was seen sailing out from the narrow bay. Some of them were so large areally that the water produced by the melting of their surfaces gathered into streams of considerable proportions. From the upper edge of a single berg in this locality, three such streams were seen to be falling, each of which carried a very considerable body of water. The bergs were remarkably regular, such serration as characterized the bergs coming from the Jakobshavn glacier being wholly wanting. Most of them had never been overturned or even tilted; yet they were measurably clean, nothing more than a little dust being in any case visible upon their surfaces. Considerable processions of bergs seemed to be coming out of the waters north

of Ubekyendt Island, and until the Svartenhuk Peninsula was reached, they were constantly in sight in great numbers.

Through Melville Bay, bergs were rarely seen. This may have been due partly to the fact that much of this stretch was passed in a foggy atmosphere, and vision was correspondingly limited. About Cape York, bergs were found in extraordinary numbers a little later, as also for a considerable distance east of this point. So abundant were they at Cape York toward the end of August that from a single position 1200 feet above the settlement just east of the Cape, about 700 were counted. Many of these were of great height, and of great areal extent as well. On the whole, this was much the noblest assemblage of bergs seen. They were not more remarkable for their size than for their freedom from débris, and for the extent to which they had been sculptured by the waves. Though without the marked serration of the bergs at some other points, their forms were often exceedingly fantastic. Here was seen the most unique berg observed at any point. From the bluff above Cape York its surface was seen to be marked by a huge, steep-sided depression, circular in outline. Its depth was considerable, its bottom appearing to be at least as low as the level of the sea. It was filled with water, the level of which appeared to correspond with that of the water in which the berg floated. The color of the water was such as to suggest that it was salt, and therefore that the depression extended quite through the berg from top to bottom. This was not, however, demonstrated. The origin of such a depression is not altogether clear, but it was probably developed while the berg was in another position. Other bergs about the Cape were notable for their huge amphitheatral reëntrants, sometimes 200 or 300 feet deep.

The bergs at Cape York were in process of rapid dissolution. At the time of our visit, the weather chanced to be sunny and warm, and the bergs appeared to have been afloat long enough for the ice to have become rotten. There was no period of more than a few minutes duration at any time during the fifty odd hours spent in this vicinity when reports due to their disruption

were not heard. These reports resembled thunder much more closely than any other familiar sound, and, awakened by them in the night, the resident of lower latitudes could hardly fail to think, at the first moment, that it was a sharp clap of thunder that had roused him, and that a violent thunderstorm was raging.

Bergs occurred in considerable numbers in Wolstensholme Sound, in the upper part of Whale Sound, in Murchison Sound, and in Inglefield Gulf and its dependencies. North of Murchison Sound and between that point and Cape Sabine, latitude 78° 45′, bergs were nowhere abundant. There was probably no time during our passage through these waters when as many as two or three were not in sight, nor were there often times when more than a dozen could be seen. They were of even less frequent occurrence between Cape York and Coburg Island. In Jones Sound they were present in moderate numbers, while along the American coast south of that point to latitude 71° 30′ they were rare. There were frequently considerable intervals where not one was in sight, while at other points considerable clusters of them came into view.

Between Disco and the Labrador coast, on the return voyage, bergs were never abundant as compared with those in many other stituations, but they were almost never wanting. An approximate idea of their abundance in these waters may be obtained by the general statement that there was rarely a time when less than half a dozen or more than forty could be seen. Their numbers diminished with increasing distance to the south, and they practically disappeared before the coast of Newfoundland was reached. On the whole, the impression gained was that a very large amount of ice is discharged from the land in the form of bergs.

The highest berg seen was probably not more than 200 feet in height. The greatest areal extent of any berg seen was probably not more than one-third of a square mile, the maximum length being, perhaps, about a mile. These figures, it is to be understood, are the results of estimate, not measurement.

The almost uniform freedom of the bergs from débris is in

itself a sufficient refutation of the idea that glacier ice is in general charged with débris. Extensive observation makes it certain that so far as west Greenland is concerned, only the lower portion of the ice of a thick glacier contains débris. There is little débris above the lowermost 100 or 150 feet of ice. As bergs are calved from massive glaciers, their lower portions doubtless carry a considerable quantity of material, but this appears to be dropped before they have proceeded great distances, for the bergs which are overturned or upturned rarely show any trace of it. On the other hand where a thin glacier reaches the sea, its bottom is not far from its top, the former being brought down nearly to the latter by melting, and the whole mass may be full of débris, without interfering with the general truth of the statement that débris does not rise any considerable distance above the bottom of the ice. From such glaciers only small bergs arise, and these may be well charged with rock rubbish from bottom to top. In spite of the possibilities in this line, and in spite of the fact that bergs from massive glaciers often capsize so as to bring their basal parts into view, rock débris on or in the Arctic bergs is yet so scarce that it would probably be within the limits of truth to say that not one berg in five hundred of those seen carried detritus of any sort, except dust which had been blown upon the glacier before the berg was detached.

Comparing the phenomena of 1895 with those of 1894, as seen by Professor Chamberlin, it appears that bergs were very much more abundant this year than last. This is in keeping with the fact that the warm season seems to have come on somewhat earlier than usual in 1895, at least in central Greenland, and that certain bays and fjords cleared themselves of ice somewhat earlier than is their wont, getting their bergs well to sea at an unusually early date, while other bays which often remain covered with ice for many years in succession, thereby holding all bergs discharged into them, this year cleared themselves, sending all their many bergs to sea.

Floe ice.—It is worthy of especial note that no trace of floe

ice was seen along the coast of south Greenland. Approaching the land further north than expeditions have commonly done, it would not have been strange had we encountered less than the accustomed amount of ice, but we neared the coast sufficiently far to the south to have encountered at least the northern portion of the stream of ice which, coming down the east coast, usually rounds the point of Greenland, and passes northward along the west coast as far as Holstensborg. The fact that no ice was seen, where a wide belt of it usually occurs in corresponding seasons, seems to mean either that it disappeared much earlier in 1895 than usual, or that it was much less abundant, or both. From various facts which came to our knowledge, it seems that the former was certainly true, perhaps also the latter.

The first floe ice was encountered in the latitude of Upernivik, a little below 73°. The small pack of ice here seen, made up in considerable part of disrupted bergs, extended out a considerable distance from the coast. The floe ice of the pack was thin, and the pans were considerably tilted. A considerable number of small bergs were held in it.

In passing Melville Bay during the last days of July, but a small amount of ice was seen. Occasional pans a few yards, or in some cases a few hundred yards in diameter, were encountered, but they were rarely so abundant as to occasion any considerable deviation from a direct course. The pans were low, usually standing no more than a foot or two out of water, and were much perforated, indicating that they were near the last stage of dissolution. East of Cape York, toward the end of August, a considerable amount of floating ice was found, but it was nowhere sufficiently close to prevent navigation. In Whale and Murchison Sounds, and in the outer portion of Inglefield Gulf, ice was so abundant as to seriously interfere with navigation during all the first half of August. North of Murchison Sound, in the northern part of Baffin Bay, there was little ice, and Smith Sound was relatively free from it, except its northern end. Here, at the entrance to Kane Basin, the ice was plentiful.

On the American coast, floe ice was somewhat abundant in

Jones Sound, increasingly so with increasing distance to the west. Forty miles or so from the entrance, navigation became difficult. South of Jones Sound, little ice was encountered until latitude 72° 30′ was reached. Here it became more plentiful, and further south, in latitude 71° or thereabouts, a very extensive pack was encountered, the east-west extent of which could have been little less than 200 miles. Its extension southward was not determined, but southwest of Disco, in latitude 66° 30′, the east edge of a considerable pack was touched, which may have been continuous northward with that which had been encountered in latitude 71°. If so, the north-south diameter of the pack must have been as much as 300 miles.

Evidences concerning recent changes of level. On the whole, the evidence gathered concerning recent changes of level along the northern coasts is rather meager. This is not to be interpreted as meaning that such evidence is necessarily wanting, but merely that it is not usually so obtrusive as to be detected upon cursory inspection. Even the absence of topographic evidences of changes of level would not necessarily mean that such changes have not taken place. The study of the coastal lands here, as elsewhere, led to the conviction that a region may be submerged and reëlevated, without preserving very distinct topographic evidence of the change.

The topography of most of the land front seen, both on Greenland and on the continent, is without any notable horizontal element; that is, terraces, beaches, etc., if present at all, are generally, though not always, so inconspicuous that they were not detected in passing, even when the course was so close to the coast as to afford excellent opportunity for studying the details of its topography.

At Jakobshavn striæ were seen on the gneiss down virtually to the level of the water. Their presence at this low level is perhaps not especially significant so far as changes of level are concerned. If the land has risen since they were formed, the shore line probably did not remain long at the level at which they occur. Their presence at the sea level, and at all higher

altitudes, would seem to mean that if the land has risen since glaciation, it rose rapidly. Nothing was seen about Jakobshavn which was taken to mean, necessarily, a recent uplift of the land, though features were seen which would be consistent with such movement.

Between Jakobshavn and Cape York but a single stop was made, but the coast (perhaps only islands) was seen almost continuously from the former place to latitude 74°. Nothing was seen in the topography at any place between these points to indicate recent changes of level, if the fjords be not considered such evidence. It should be stated, however, that the course of the *Kite* was frequently so far from shore, that minor, or even reasonably distinct, topographic evidences of rise might have escaped notice. Further north, positive evidences of recent rise were seen at various points. Thus there are well defined terraces on the east side of Saunders Island in latitude about 76° 35′. The elevation of these terraces was not determined as no landing was made on the island, but the highest may have been something like 100 feet above the water. Again, in Olrik's Bay, a dependence of Whale Sound, just above the 77th parallel, there are considerable deposits of sand containing abundant marine shells of species still living along the shore, at elevations ranging up to 150 feet at least. These sands are conclusive proof of recent elevation of the coast in this region by an amount equal to the height of the sands themselves, yet topographic evidence of this change of level is nowhere conspicuous along any part of the bay seen, and at many places is altogether wanting. The end of a large glacier descending toward the bay from the elevated lands on the south, rests on and conceals the upper part of these shell-bearing sands.

Nowhere else in Whale Sound or Inglefield Gulf was anything seen which seemed to necessitate the conclusion that the land has recently risen or sunk. Near the west end of Herbert Island, on the south side of Murchison Sound, there is a terrace which very likely signifies recent elevation. It is less well defined than that of Saunders Island, and its altitude is comparable. Elsewhere about the island distinct terraces are wanting.

The most conspicuous terraces seen were in the vicinity of Littleton Island, in latitude about 78° 30′. Here on the mainland coast, there is a notable series of terraces, at least three in number, which seemed clearly to have been fashioned by the waves. Opportunity was not afforded for their measurement, but the highest could hardly have been less than 300 or 400 feet.

It will be seen that the points where positive evidence of recent rise was found are distributed in latitude between 76° 35′ and 78° 30′, a stretch of something like 120 miles; but within this distance there seemed to be complete absence of evidence of recent submergence at most points. If one may trust topographic evidence, and such evidence as interrupted study on the shores themselves furnished, it would be as rational to conclude that the coast through this region has risen at certain points, while others have remained stationary or have subsided, as to conclude that it has risen at all points because it has risen at some. It is not believed, however, that anything less than an uninterrupted study of the coast through long stretches will afford positive evidence concerning the point in question, and the absence of topographic evidence of recent elevation at many points is therefore not interpreted as necessarily meaning absence of recent elevation at those points.

On the American coast a somewhat similar condition of things exists. On Smith Island, in Jones Sound, there is positive evidence of recent elevation to the extent of fifty feet, and less satisfactory evidence of a much more considerable rise. South of Jones Sound a horizontal element in the coastal front is often wanting, though sometimes present. It was somewhat conspicuous on Philpot Island, latitude 75°, though no landing was made at this point, and the significance of the horizontal element was therefore not determined. Suggestions of terraces were also observed at some points on Bylot Island. At Dexterity Harbor, about 72°, opportunity was afforded for more careful examination of the evidence bearing on this question, and here there was positive evidence of recent elevation to the extent of something like 480 feet, aneroid measurement. Beaches and flats of limited

extent succeeded each other at frequent intervals up to this level. Along the line of ascent, seven tolerably well defined beach lines were noted, while on the line of descent, but a short distance from the former, two more were counted. From a short distance off shore these successive stages were altogether unseen, although the whole of the considerable stretch of territory below 500 feet had the general aspect of a marine plain. It is probable that detailed examination of the coast at other points would give specific information, which was not detected from the *Kite*, concerning the stages of rise

In conclusion it may be stated that while recent changes of level have certainly taken place at some points, and that they locally amount to several hundred feet, observations were too disconnected and too meager to make out the general system according to which they took place, or the general principles governing them.

ROLLIN D. SALISBURY.

A CIRCUM-INSULAR PALÆOZOIC FAUNA.

CONTENTS.

Introduction.
Zoölogical Provinces of Devonian Time.
Distribution of Land and Water during Devonian Time.
Union of Eastern and Western Devonian Provinces.
Generic Evidence of the Origin of the Littoral Fauna about the Ozark Island.
Specific Evidence of the Origin of the Littoral Fauna about the Ozark Island.
Conclusion.

INTRODUCTION.

Zoölogists who have turned their attention to the geographic distribution of animal life on the earth at the present time, have divided it into numerous zoölogical provinces. The marine zoölogical provinces are separated by three classes of barriers, (1) Climatic, (2) Land, (3) Abyssmal. Each one of these establishes a limit to the migrations of marine life. There is no reason to doubt the existence of zoölogical provinces in past time similar to those existing today, with the same sorts of barriers, but ever changing with the progress of time.

These zoölogical provinces of past time give rise to problems with which the palæontologic geologist has to deal. Unfortunately the ancient barriers are obscured or lost, being buried by later formations, or the sea, or carried away by erosion, and it falls to the investigator to reconstruct the barriers from a study of the faunas and of the stratigraphy.

Zoölogical provinces of Devonian time.— During Silurian time the faunas of eastern North America and northern Europe were intimately related. Many species were common to both regions, and there seems to have been freedom for intermigration between the two. With the beginning of Devonian time these two regions became isolated. The faunas in each continued their evolution, but each in accordance with the conditions of its own environ-

ment. At the period of deposition of the Hamilton beds in New York, a distinct fauna had to come to exist in each of these two areas.

The east American fauna of this time has been described and illustrated chiefly in the various reports of the New York state geologist. From studies of the South American Devonian fauna, chiefly those of Dr. A. Ulrich,[1] it has been shown that the east American Middle Devonian fauna is related to the South American fauna. The peculiar genera *Tropidoleptus* and *Vitulina* are characteristic of these two regions, being unknown in the European and west American Devonian faunas. Besides these genera, there are other bonds of relationship between the faunas. This east American fauna inhabited an area bounded on the north by the nucleus of the North American continent and on the east by the land area lying at that time to the east of the present Appalachian region. It did not extend westward beyond the Mississippi River. From its relationship to the South American faunas, we may conclude that it extended far to the south.

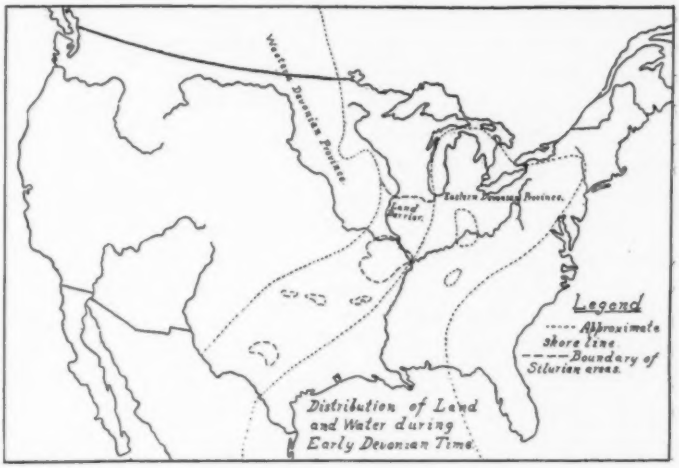
The contemporaneous European fauna was largely developed in central Europe, in the Ural Mountain region, and extended across Asia and into the western part of North America. In America its most typical development was in the far northwest. It was first described by Meek[2] from the Mackenzie River basin, and has lately been much more completely described by Whiteaves.[3] It extends southeastwardly, and, in the so-called Hamilton of Iowa, it reached the Mississippi River.

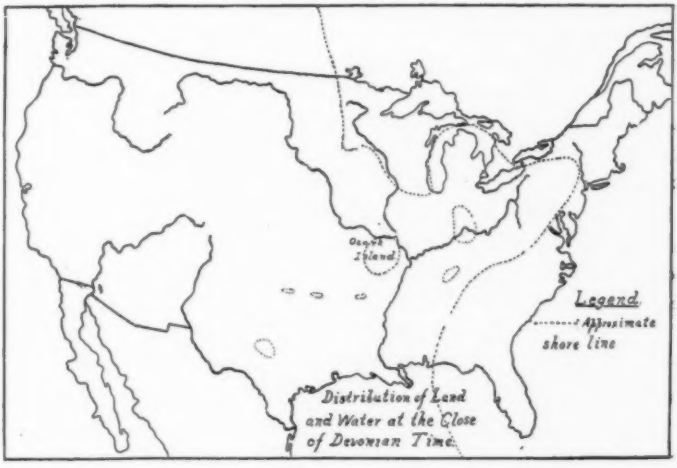
Distribution of land and water during Devonian time.— In seeking for the barrier, which must have existed during the greater part of Devonian time, near the present location of the Mississippi River, the presence of a land barrier seems to be necessarily presupposed. The stratigraphy of the region admits of this conclusion. Along the southern border of the Silurian peninsula, extending southward and including a large part of

[1] Beiträge zur Geol. und Pal. von Südamerika, I, Paläozoische Versteinerungen aus Bolivien.

[2] Trans. Chic. Acad. Sci., Vol. I. (1868).

[3] Cont. to Canadian Pal., Vol. I., Part III. (1891).


Western Devonian Province.
Eastern Devonian Province.
Land Barrier.
Legend
Approximate shore line
Boundary of Silurian areas.
Distribution of Land and Water during Early Devonian Time.


Oneota Island
Legend
Approximate shore line
Distribution of Land and Water at the Close of Devonian Time.

Wisconsin and the northern portion of Illinois, rocks of much younger age lie upon the Silurian beds, indicating that during a long period between Silurian and Carboniferous time this peninsula extended far to the south. The Ozark Silurian or Ordovician region has also lying upon its flanks rocks of much younger age, indicating that during the greater part of Devonian time it was a body of dry land of more than the present extent of the older rocks. There seems to be good reason, therefore, to suppose that during this period the Wisconsin peninsula and the Ozark Island were joined. This, however, would not alone form a sufficient barrier to separate the two faunas, as they could easily migrate around the southern end of this peninsula. There are, however, small patches of Silurian rocks exposed in Arkansas, Indian Territory and Texas, and all of these are surrounded in a similar way by rocks of much younger age, and this suggests the probable extension of this land barrier far to the southwest. Furthermore, the presence in the east American Devonian fauna of representatives from the South American province necessitates a shore line along which the migration could have taken place. This suggests the extension of this land into South America. With the existence of such a land tract the separation of the two Devonian faunas would be effectual.

If the conclusions of the last paragraph are correct, the Ozark region was not an island during earlier Devonian time, but was included in a long peninsular extension of the ancient northeastern land, or more probably in an isthmus joining it to some larger body lying to the southwest. By a partial submergence of this peninsula or isthmus the Ozark Island was formed. The depression of this land area was neither sudden nor continuous, but the movements were oscillatory in their nature.

Union of eastern and western Devonian provinces.—The earliest evidence of the union of the two seas on either side of this narrow strip of land is found in the appearance of an entirely foreign fauna in the midst of the Hamilton beds of New York. This is the Cuboides fauna of the Tully Limestone. From a

study of this fauna Professor Williams[1] has shown that it was not the genetic successor of the fauna immediately preceding it, but that it was entirely foreign to the area, and that its relationships were with the Devonian faunas of western and northwestern America, which in turn were intimately related to the European middle Devonian faunas.

This earliest submergence of the Ozark Isthmus was not permanent. The two seas were not in communication for a sufficient period to admit of any extensive intermigration of the faunas. A colony from the west escaped into the east and found its way into the New York region, where it occurs in the Tully limestone. From the oscillatory natures of the movements of this region during its period of submergence, there is reason to expect that there will be found in the Devonian beds along the border line between the eastern and western provinces a mingling of the two faunas. This need not necessarily occur in the same beds at first; the faunas might appear in alternate layers. Much yet remains to be done, however, upon the details of the stratigraphy and palæontology of this region. None of the present records enter into sufficient detail to be available for a conclusive study of the subject.

On the final submergence of the connecting tracts and the formation of the Ozark Island—having approximately the area of the present exposure of the older rocks — the faunas of the two provinces had an unlimited opportunity to intermingle. It is this circum-insular fauna, found embedded in the strata of the Chouteau group,[2] which is the subject of chief consideration in this paper.

The study of island faunas has always possessed the greatest interest to evolutionists. In his observations upon island faunas during his trip around the world, Darwin found many of the facts which led to his proposal of the theory of natural selection.

[1] Bull. Geol. Soc. Am., Vol. I, pp. 481–500 (1890).

[2] The author may be criticised by some for using the name Chouteau, for these beds have of late come to be generally considered as contemporaneous with the Kinderhook, and designated by that name, which was applied at an earlier date. There is no doubt in the author's mind of the contemporaneity of the Kinderhook and Chouteau, but the latter term is used as a convenient discriminative formation name of a local nature to designate the beds deposited on the immediate shores of the Ozark

The studies of Wallace have elevated island life into a distinct field of investigation. In the study of an island fauna, whose records, and even the island itself, are buried in the rocks, the task of interpretation becomes especially difficult. The conclusions to which one may arrive, however, equal in importance those reached in the study of recent island faunas. The study of the littoral faunas has much the same nature and importance as that of the islands themselves. So far as the writer is aware, however, there never has been published the results of a special study of a circum-insular fauna of palæozoic time.

In the detailed study of any fossil fauna the palæontologist must ask himself of each individual genus and species, is this an evolution form, or is it a migration form? Every genus or species, in whatever geologic or geographic position it may be found, falls into one of these two categories. Either its ancestors have lived in the same geographic area where it exists, or they lived in some other part of the world, and the genus or species is in the particular position where it is found, through migration from the original center of evolution. This migration may have occupied a series of generations. Very often these questions cannot be answered, but in most cases an answer can be found for those forms which give character to the fauna.

From the nature of the case the fauna of the Chouteau group was composed necessarily of migration species. An area of land had become sea-bottom, having no preëxisting marine fauna, it had to be peopled, if peopled at all, by organisms which come in from without. This does not, however, make it necessary that the migration should have been a distant one. On a critical examination of the fauna it is found that the ancestry of the individual genera and species can be traced back to two different sources. These are the middle and lower Devonian faunas of the East and the Devonian fauna of Europe and the West.

Generic evidence of the origin of the littoral fauna about the Ozark

Island. The typical Kinderhook beds were deposited nearer the shore of the mainland of that time and under somewhat different conditions, and it might be misleading to use the term in this connection. It is only the circum-insular fauna as found in the Chouteau beds that is considered here.

Island.— In the following table all the genera occurring in the Chouteau group are tabulated with their geologic range[1] and geographic distribution, and from this table the generic evidence of the origin of the fauna may be seen.

	Chouteau Group	East American Devonian Province	West American and European Devonian Province.	American Silurian	European Silurian
BRACHIOPODA.					
Athyris	x	x	x	x	x
Camarophoria	x		x		
Chonetes	x	x	x	x	x
Cyrtina	x	x	x	x	x
Leptæna	x	x	x	x	x
Lingula	x	x	x	x	x
Orthothetes	x	x	x	x	x
Productella	x	x	x		
Productus	x				
Ptychospira	x		x		
Rhipidomella	x	x	x	x	x
Pugnax	x		x		
Rhynchonella	x	x	x	x	x
Schizophoria	x	x	x	x	?
Spirifer	x	x	x	x	x
LAMELLIBRANCHIATA.					
Aviculopecten	x	x			
Cardiopsis	x	x			
Edmondia	x	x			
Entolium	x				
Grammysia	x	x	x	x	
Pernopecten	x				
Promacrus	x				
Pterinea	x	x		x	
Sphenotus	x	x			
GASTEROPODA.					
Bellerophon	x	x	x	x	x
Eccyliomphalus	x	x	x	x	x
Euomphalus	x	x	x	x	x
Loxonema	x	x	x	x	x
Platyceras	x	x	x	x	x
Porcellia	x	x	x		x
Straparollus	x	x			
CEPHALOPODA.					
Goniatites	x	x	x		
Nautilus	x	x	x	x	x
Orthoceras	x	x	x	x	x

[1] The range of the genera above the Chouteau group is not tabulated. In a future paper, now in preparation, the history of the faunas of the overlying Osage group will be considered.

	Chouteau Group	East American Devonian Province	West American and European Devonian Province	American Silurian	European Silurian
PTEROPODA.					
Conularia	x	x	x	x	x
Hyolithes	x	x	x	x	x
CRINOIDEA.					
Agaricocrinus	x				
Amphoracrinus	x				
Cyathocrinus	x	x	x	x	x
Dorycrinus	x		x		
Gennaeocrinus	x	x			
Platycrinus	x	x			
Scaphiocrinus	x	x			
Schizoblastus	x				
CORALS.					
Amplexus	x	x	x	x	?
Chonophyllum	x	x	x	x	x
Cyathophyllum	x	x	x	x	x
Leptopora	x				
Lithostrotion	x				
Michelinia	x	x			
Microcyclus	x	x	x		
Palæacis	x				
Syringopora	x	x	x	x	x
Zaphrentis	x	x	x	x	x
TRILOBITA.					
Brachymetopsis	x				
Phillipsia	x		x		
Proetus	x	x	x	x	x

In the foregoing table it is seen that the genera, exclusive of those peculiar to the Chouteau, with but three exceptions, may be divided into three groups. (1) Those common to the Chouteau and the east American faunas. (2) Those common to the Chouteau and the west American or European faunas. (3) Those common to all these faunas. It is important to observe that the genera of the last class are all older than those peculiar to only one of the two Middle Devonian provinces. As shown in the table they extend back into the Silurian time when the two areas were united. After the isolation of the two regions as distinct Devonian provinces, new genera originated, and those thus originating in the separate provinces were different.

The exceptions to this rule are: *Productella*, *Goniatites* and *Microcyclus*. The fact of the recorded distribution of *Productella* points either to a dual origin of the genus, or to an imperfection in the record, or, possibly to an exceptional migration across or around the barrier in spite of the general effectiveness. The name *Goniatites* is applied to a heterogeneous assemblage of forms, which have been divided into numerous genera by Hyatt and other recent writers, and if the Chouteau species were referred to these more limited divisions, it is probable that they would not appear as exceptions. *Microcyclus* occurs in the Devonian fauna at Devil's Bake Oven in southern Illinois, where the eastern faunas approach nearest geographically to those of the west. It is possible that this fauna lived during the period of submergence of the land barrier, and that *Microcyclus* in this locality is really a representative of the western and not of the eastern fauna.

Taking the generic evidence as a whole, it points to the dual origin of the fauna.

Specific evidence of the origin of the littoral fauna about the Ozark Island.—In the consideration of the specific evidence of the origin of the Chouteau fauna each species has been studied with special reference to its evolution from preëxisting species. As might be expected, the evolution of the species can be traced in only a few instances comparatively, but this evidence also, so far as it is available, points to the dual origin of the fauna. Each of the species whose evolution can be traced will be briefly considered.

Athyris hannibalenis, Swallow. This species is not uncommon in the yellow Chouteau Limestone. It most closely resembles *A. lamellosa*, L'Eveille, of the succeeding beds. It is generally less transverse than that species, though this character is variable, and individual specimens may be found which are quite equal to *A. lamellosa* in this respect. The concentric lamellæ on the exterior of the shell are somewhat closer together than in *A. lamellosa* from the Burlington Limestone. It is intermediate in its characters between *A. spiriferoides*, Eaton, of the New

York Hamilton beds, and *A. lamellosa*, of the Burlington Limestone, though it approaches much closer to *A. lamellosa* than to *A. spiriferoides*. A well-preserved exfoliated specimen from the Chouteau limestone near Springfield, Mo., closely resembles a specimen of *A. spiriferoides*, which is in the same condition of preservation, from the black calcareous layers of the Hamilton series of New York.

Athyris proutii, Swallow. Though this species has never been figured, it is well characterized and easy of recognition. Specimens have been examined from the typical locality, and compared with those from the base of the Chouteau group, near Springfield, Mo., they cannot be separated. The species is not apt to be confused with any other American form, but it is similar to and possibly identical with *A. reticulata*, Gosselet,[1] of the Middle Devonian of Europe. American specimens agree closely with Tschernyschew's[2] figures of this species from the Ural Mountains, and the surface ornamentation of the American form is identical with the European.

Leptæna rhomboidalis, Wilckins. This cosmopolitan species is one of the most interesting in the whole fauna. It occurs in all the beds of the Chouteau group and extends up into the Burlington Limestone. In studying its geographic and geologic distribution, it is found not to be recorded in the Devonian fauna of the west, though it does occur in Europe. It occurs abundantly, however, in the Lower and Middle Devonian faunas east of the Mississippi River. Its origin in the Chouteau fauna may probably be traced to the eastern Hamilton fauna.

Orthis (*Rhipidomella*) *michelini*. L'Eveille. Although the subgenus *Rhipidomella* is present in the European Devonian faunas, it does not occur in those of northwestern America. The form from which *R. michelini* has its origin is *R. vanuxemi*, Hall, of the eastern Hamilton beds. Indeed, it is most doubtful

[1] *Spirigera* (*Athyris*) *reticulata*, GOSSELET, Ann. Soc. Geol. du Nord. Vol. IV., p. 312, Pl. III., Figs. 3 a–f (1887). *Spirigera reticulata*, GOSSELET Equisse Geol. du Nord de la France; Pl. VI., Fig. 6 (1880).

[2] *Athyris reticulata*, Tschernyschew, Die Fauna des Mitt. und Ober Devon am des W. Abhange des Urals., p. 57, Tab. X, Figs. 16 a–d (1887).

whether the two forms should be separated at all. Oftentimes individual specimens from the Chouteau beds cannot be distinguished from individual specimens from the New York Hamilton beds, except in color, the form being essentially the same. The presence of this form in the Iowa Devonian beds may be attributed to the nearness of that area to the border line between the two provinces during the period of submergence of the land barrier.

Orthis (*Schizophoria*) *resupinata*, Martin. American specimens of this species have been described as *O. swallovi*, Hall,[1] but it is impossible to separate the American specimens from European examples. The ancestor of this species is most certainly to be found in *O. striatula*, Schl. of the European Middle Devonian. In the beds of the Chouteau group many intermediate forms between the two species are found. The facts of the distribution of *O. striatula* are most interesting. It occurs in the Western American Devonian faunas under the name *O. iowensis*, Hall. In the eastern portion of America it appears first in the Tully Limestone under the name of *O. tulliensis*, Vanuxem. This represents its first eastward migration. Later, when the land barrier was more fully removed, it again migrated to the east, and is found in the Chemung faunas under the name *O. impressa*, Hall.

Productella hallana, Walcott (= *P. dissimilis*, Hall). This peculiar little species occurs abundantly in the Devonian fauna of the west and in Europe, and is also present in the very lowest beds of the Chouteau group near Springfield, Mo. It is also present in the very lowest beds of the Chemung group in New York.

Productella pyxidata, Hall. This species is closely related to *P. subaculeata*, Murch., of the European Devonian, and its ancestry may apparently be traced to that species.

Rynchonella (*Pugnax*) *acuminata*, Martin. This type of Rynchonella is wholly unknown in the east American province until after the period of immigration from the west, when it occurs with *Productella hallana*, in the very lowest beds of the Chemung

[1] Geol. Surv. Iowa, Vol. I., Pt. II., p. 579, Pl. XII., Figs. 5 a–b (1858).

group in New York. It also occurs, as does *P. hallana* in the lowest beds of the Chouteau group.

Spirifer cf. compactus, Meek. A common species in the Chouteau beds, is remarkably like Meek's illustrations of *S. compactus*[1] from the Mackenzie Valley. If not referable to that species it can most certainly be considered as its genetic successor.

Spirifer marionensis, Shumard. This is one of the most characteristic of Chouteau species. The form to which it is most closely related, through *S. Whitneyi*, Hall, of the Iowa Devonian, is *S. verneuili*, Murch. Some of the variations of this most variable species[2] are closely similar to individual specimens of the American *S. marionensis*.

Eccyliomphalus paradoxus, Winchell. The nearest ally and probable genetic predecessor is found in *E. laxus*, Hall, from the Devonian of the east.

Loxonema cf. hamiltonae, Hall. In beds of the Chouteau group near Springfield, Mo., is a little species of *Loxonema* which can scarcely be separated specifically from this species of the New York Hamilton beds.

Conclusion. From a consideration of all the evidence, the fauna of the Chouteau group is seen to be the resultant of the union of the two distinct faunas. Each of the original faunas is undoubtedly Devonian, but the resultant fauna as a whole has the strongest Carboniferous affinities. Before the removal of the barrier which kept them apart, these two faunas had lived under similar physical environments, and it is probable that either of them could have lived alone on the shores of the Ozark Island without undergoing any considerable change. But on the intermingling of two such distinct faunas, a fierce struggle for existence arose between them. In this struggle the most hardy elements of the two hardy faunas survived, and in their union resulted a most vigorous fauna which gave character to succeeding faunas for a long period of time, and whose influence was far

[1] Trans. Chicago Acad. Sci. Vol. I., p. 102 (1868).

[2] Etude sur les variations du *Spirifer verneuili*, par J. Gosselett Mem. Soc. Geol. du Nord. (France) Tome IV., I., pp. 1–61, plates I.–VII. (1894).

reaching.[1] Many species became extinct and many new ones were initiated, while several genera appear here for the first time. The most important of these new genera is *Productus*, which attained at its period of initiation almost its complete range of primary differentiation. In the Chouteau Limestone occur species of this genus which represent the three subdivisions, including the greater number of all its known species, *i. e.*, the groups of *P. semireticulatus*, *P. cora* and *P. punctatus*. The genus *Productus* is one of the most characteristic of Carboniferous time.

It is of interest and value, for purposes of correlation to trace the further migrations of the fauna of the West Devonian province. When the land barrier was permanently removed, one detachment migrated eastward into New York and gave origin to the faunas of the Chemung epoch. In the Chemung fauna the same two elements exist as in the Chouteau fauna, but the western and European element is so much in the ascendancy, that the fauna has a very different aspect. It seems that the foreign fauna was much better adapted to the conditions of environment than the native one, and so, instead of a general mixture of the two, such as took place on the shores of the Ozark Island, the native fauna was driven out by the foreign one, only a small element of it being absorbed.

In the very base of the Chemung[2] are two extremely interesting species, *Rynchonella* (*Pugnax*) *acuminata*, Martin, and *Productella hallana*, Walcott. These same two species also occur

[1] It is not the intention of the author to convey the idea that the fauna of the Mississippian Series originated exclusively on the shores of the Ozark Island. On the shore of the mainland adjoining, the same opportunity for the intermingling of the two faunas existed. The Chouteau fauna is alone treated in the present paper because it is this fauna with which the author is familiar. The whole subject of the origin and evolution of the Mississippian faunas involves a detailed study, not only of the Chouteau and Kinderhook faunas and their successors, but also of the Waverly and Marshall faunas of Ohio and Michigan. It is believed that the key to the whole problem is to be found in the dual origin of the faunas as set forth in the present paper.

[2] On a remarkable Fauna at the base of the Chemung Group in New York. H. S. Williams. Am. Jour. Sci., Vol. XXV., p. 97 (1883). Fauna of the Chemung Beds at High Point. J. M. Clarke. Bull. U. S. G. S. No. 16., p. 72 (1885).

in the *base* of the Chouteau group. Both of them, or nearly related species, are abundant in the Devonian beds of the western province. In the eastern province they are unknown, and nothing like them occurs before the immigration of the western fauna. Appearing as they do for the first time after the removal of the land barrier between the east and west, in these two localities, southern Missouri and New York, they furnish good ground upon which to correlate the formations in which they occur in the two regions, making the base of the Chouteau group contemporaneous with the base of the Chemung group of New York.

In the early reports, the Chouteau beds were referred to the Chemung group, but at the present time they are generally considered as younger than the Chemung because the fauna as a whole is more nearly related to the succeeding Carboniferous than to any Devonian fauna. Continued investigation seems to substantiate the old view of the Devonian age of the Chouteau beds. While *the Chouteau fauna is not the Chemung fauna*, the two lived contemporaneously. The differences between them are geographic in their nature and origin, rather than chronologic.

The dividing lines between time periods such as are understood by the terms Devonian and Carboniferous must be taken arbitrarily in their closer application, whatever may be the distinctness of the periods from a general point of view. It is incompatible with modern doctrines to conceive of a sudden change through which the Devonian faunas of the world became extinct and the Carboniferous faunas simultaneously initiated. The Carboniferous fauna must have begun to take its origin in Devonian time, in the midst of Devonian faunas. A plane extended around the world between the formations having faunas most closely allied to those below, and the formations whose faunal alliance is upward, would not be a contemporaneous division. If time periods are arbitrarily separated by horizontal time lines, or time planes, of necessity it follows that cases will be observed where faunas with Carboniferous alliance will have lived before the arbitrary Carboniferous-Devonian time line, and faunas with

Devonian alliance will have lived after it.[1] The Chouteau fauna is a good illustration of a fauna with Carboniferous affinities living before the close of Devonian time, as divisions are usually shown.

STUART WELLER.

LABORATORY OF PALÆONTOLOGIC GEOLOGY,
UNIVERSITY OF CHICAGO.

[1] An illustration of the persistence of a Devonian fauna is seen in the fauna of the Spring Creek Limestone near Batesville, Ark. See: The Recurrence of Devonian Fossils in Strata of Carboniferous Age. H. S. Williams, Am. Jour. Sci., Vol. XLIX., p. 94 (1895).

EXPERIMENTS IN ICE MOTION.

In a previous study the author became convinced that a definite relation exists between certain deposits of glacial débris and the topography of the surface over which the ice from which they were deposited had just passed. It seemed that this relationship could only be explained by the existence of differential movements or currents in the ice bottom, and it was to determine the existence of these and, to as great an extent as possible, their nature, that the following experiments were undertaken.

Much discussion has taken place over the method of motion in glaciers and the condition of the basal portion of a thick bed of ice, such as a continental glacier. The upper parts of glaciers are known to be practically rigid, while the basal portions, as far as can be judged from the resultant topography, is possessed of differential movements, *such as might take place in a viscous body*. Whether the mobility of the bottom is caused by regelation, granulation or true viscosity, the currents would be the same and it was these alone that the author attempted to investigate.

Under the assumption that the currents were such as could take place in a viscous body, the substance chosen to experiment with was wax or paraffine in which was dissolved a quantity of refined petroleum to lower the melting point. The paraffine was melted and allowed to cool to a temperature such that it would just give under its own weight, great care being taken to keep it of an equal temperature and softness throughout The wax was than forced through long, narrow boxes, open at both ends, by means of closely fitting plungers, and caused to pass over obstructions of various kinds placed in its path. It was then allowed to cool in the box and sawn or sliced into sections. The boxes used were of varying lengths and generally about twice as high as broad, allowing for a vertical play of currents

as the class of obstructions it was desired to study would produce only this kind. The face of the obstructions extended entirely across the box and was rounded but quite abrupt. The inside of the boxes was planed smooth and then rubbed with olive oil to reduce friction and consequent drag on the sides (which it was feared would influence the results of the experiment) to as great an extent as possible. In experiments upon the effect of drag it was found necessary to increase it artificially. The boxes were fastened together by screws to facilitate handling.

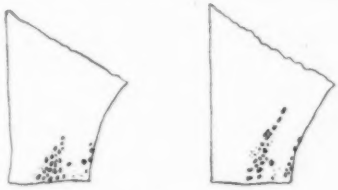


FIG. 1.

In forcing the paraffine through the boxes the strength of the operator was generally found sufficient to produce the necessary rate of motion which did not exceed a foot in fifteen or twenty minutes and was, when necessary, further reduced by pauses in the operation. In order to trace the currents thin lines of powdered coal or galena and layers of darkened wax were used. When the wax was being packed in the box the different layers were fused on the surface with a Bunsen burner and allowed to stand in contact for a few moments before being moved in order to form a perfect union and regain a temperature similar to the residue of the wax.

THE EXPERIMENTS.

Experiment 1.—A box 6 by 6 inches and 12 inches long was furnished with an escarpment 1 inch high which extended to the rear of the box. Coarsely powered galena was sprinkled upon the floor of the box and the wax packed upon it. The wax was then subjected to a shove of about 3 inches. The result is shown in Fig. 1.

Experiment 2.—A box 3 inches high by 3 inches wide was furnished with an escarpment 5/8 inch high. The wax was provided with a basal layer of darkened wax 1/2 inch thick. It was shoved 7 or 8 inches. Fig. 2.

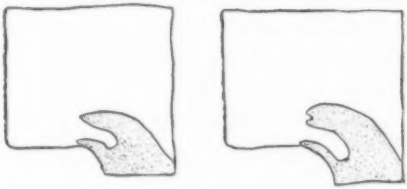


FIG. 2.

Experiment 3.—The same box as in Experiment 2 was provided with an escarpment 1 inch high and the wax provided with a thicker basal layer of darkened wax. The same length of shove was given. Fig. 3.

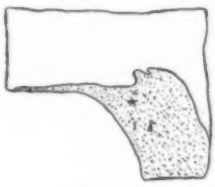


FIG. 3.

Experiment 4.—A box 3 1/2 inches wide and 6 inches high with an escarpment 7/8 inch high. The wax was provided with a basal layer of darkened wax and a little light wax, 3/4 inch, was packed between it and the escarpment. It was shoved about 13 inches. Fig. 4*a*.

Experiment 5.—The box used in Experiment 4 was provided with an obstruction 7/8 inch high and 2 1/4 long with an abrupt front and gently sloping rear. The wax was furnished with a basal layer of darkened wax and shoved about 10 inches. Fig. 4*b*.

Experiment 6.—A box 3 1/2 by 6 inches with an escarpment 1 1/2 inches high. The wax was provided with a basal layer of dark-

b *a*

FIG. 4.

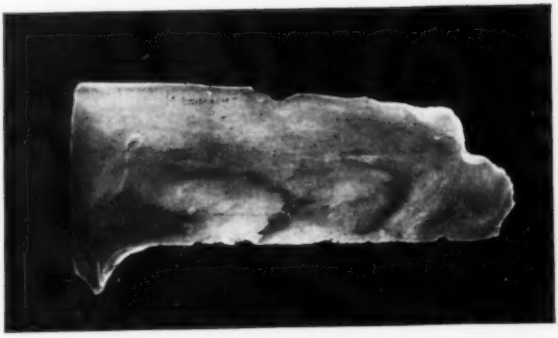


FIG. 5.

ened wax and a couple of dark lines at intervals of about ¾ inch above it. It was shoved about 12 inches, Fig. 5 (by transmitted light).

Experiment 7.—A box 4 feet long was furnished with two escarpments each ⅞ inch high. The first extended one-half the

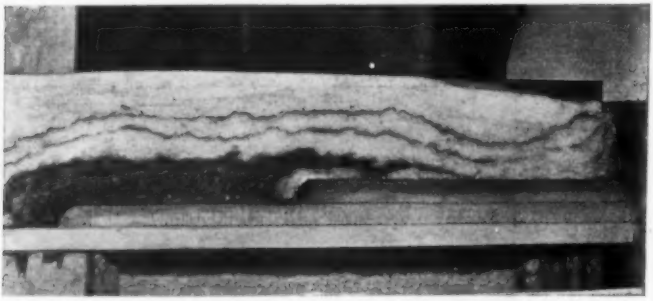


FIG. 6.

length of box and the second 14 inches from the back and lay upon the first. The wax was provided with a basal layer of dark wax and two dark lines. The shove was 18 inches. Fig. 6.

Experiment 8.—The arrangement in Experiment 7 was altered by taking 1½ inches from the upper escarpment and removing a piece 5 inches long from the lower, leaving a valley with an obstruction of 6¼ inches in front of it. The form of the base may be seen in the figure. The basal layer was substituted by a line at the level of its top. The shove was 18 inches. Fig. 7.

Experiment 9.—The last two escarpments in Experiment 8 were removed and one of the same height and 7½ inches long substituted, having a valley 10 inches long. The lines were as in Experiment 8. The shove was 18 inches. Fig. 8.

Experiment 10.—The same arrangement as in Experiment 9, but the wax was allowed to remain at rest five minutes with its front in the valley between the two escarpments. Fig. 9.

Experiment 11.—The valley was decreased to 7¾ inches by

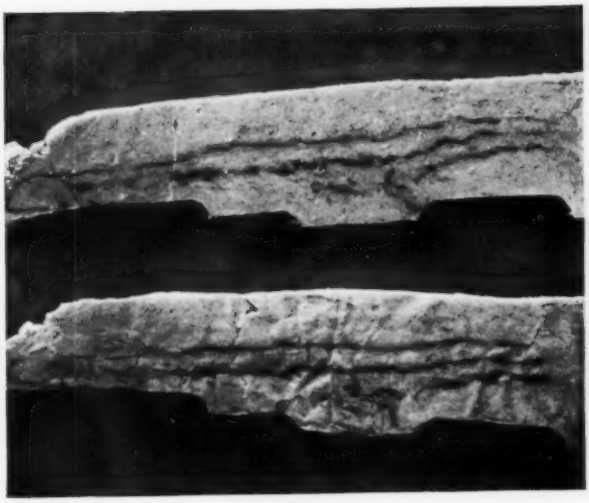


FIG. 7.

FIG. 8.

elongation of the rear escarpment and the number of lines in the wax reduced to two. Fig. 10.

RESULTS OF EXPERIMENTS.

An inspection of Figs. 1, 2, 3, 4 and 5 will show a very decided upward current produced in the basal portion of the

FIG. 9.

wax. The current starts somewhat back from the escarpment and travels up and over it in an arch, leaving between itself and the top and rear portions of the escarpment a layer of white wax seemingly unaffected by the movement.

A second current is shown in the same plates creeping up close to the face of the escarpment and reaching to its top, where, upon a flat surface it may spread out closely applied to the surface, as in Fig. 3, or rise a little above it as in Fig. 2. In every case it will be noticed that this current is a very minor portion of the wax movement. In case of a further movement

of the wax the evidence of two currents, so clear in Fig. 2 is obscured, as shown in Fig. 6. A close examination, however, reveals their continued presence.

In the case of an escarpment or obstruction with a subsequent declivity the basal layer is continued out into the wax from the top of the escarpment or obstruction as a narrow line. Fig 4*b*.

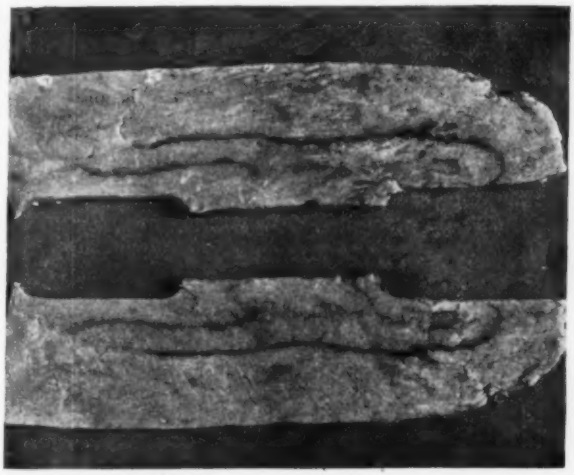


FIG. 10.

The part continued in the line is, possibly, the part noticed in Fig. 2, adhering to the face and top of the obstruction while its main current can be seen rising in an arch behind. The same feature is less prominently shown in the experiments where lines were used instead of the basal layer of darkened wax. Another point to be emphasized is the arch-like course taken by the upper and principal current. Rising abruptly a little way back from its front the currents extend to a considerable distance in its rear, where they descend in a much more gentle curve towards a point much farther from the escarpment than it originated. At all points it is free from contact with the escarpment. This

is shown in Fig. 5, and in the simplest form in Fig. 4*a*, and in the upper lines at the second escarpment of Fig. 6.

In Fig. 5 the arch is shown complicated by a most important agency, namely, drag. This will be shown to be the source and explanation of some of the complicated phenomena observed in the wax. Experiment 6 was designed to determine the effects upon the moving wax of the drag from the bottom of the box. As noted above, it was necessary to induce drag. This was done by a pause in the shove allowing the wax to flatten slightly and adhere to the bottom. The currents marked by the lines in the wax descended upon the surface in the rear of the escarpment and where there retarded by friction, the upper part was carried forward by the general movement of the wax and the result is a curve reaching far to the rear of the escarpment, with a sharp curve passing back much closer to the escarpment and reaching the bottom of the box. Fig. 5 and the anterior portion of the wax in Figs. 7, 8 and 10 (in the latter it is to be noted that the curve is flattened by the unavoidable falling forward of the front of the wax as it cooled in its box).

It was now desired to ascertain what became of the recurved currents under conditions of recurring obstructions and of being carried forward over a plane surface. The first of these questions was answered incidentally in experimenting on the second, and its consideration may be retained till the last.

Experiments 7 to 11 were designed to answer the first question and the results are seen in Figs. 6, 7, 8, 9 and 10.

Experiment 7 was considered a failure because of the great reduction of the internal capacity of box and consequent acceleration of the motion of the wax and the inability of the currents to reach the bottom and become affected by drag. Fig. 6.

Experiment 8. The narrow valley and proximity of the escarpments produced a clogging of the wax and almost total disappearance of the characteristic curve, however enough remains to prove its existence. The lower layer and the second layer show drag respectively after the first and third escarpments, while the upper recurves only at the extremity.

The most important feature of the experiment is shown in the sharp angulation of the recurved portion of the upper line and of the folding upon themselves of the lower with consequent stretching out in a series of detached portions. Fig. 7.

Experiment 9 shows the same destruction of the lower line and a most remarkable elongated folding, also a recurving of the two upper ones as they arch over the last escarpment. Fig. 8. The advanced position of the rear of the upper lines is another evidence of the drag.

Experiment 10 shows identical phenomena with sharply angulated recurve just rising over an escarpment. Fig. 9.

Experiment 11 shows another form of the loops in passing an escarpment and the stretching with consequent approximation of the two ends of the loop caused by the horizontal progression of the wax. Fig. 10.

The effect produced on the loop by progression on a plane surface is clearly exemplified by the basal line in Figs. 7, 8 and 9, and in the loop at the extremity of Fig. 10. The action is to produce a stretching and close refolding of the loops, then a breaking up of the loop into sections. The result is the formation of laminæ, not of great extent themselves but in series of great extent.

It is necessary to again call attention at this point, to the phenomena shown in Experiment 5, Fig. 4*b*. The basal, dirty layer of the wax, upon reaching the summit of a rounded obstruction did not follow down the far side of the obstruction, but was carried forward in a straight line into the body of the wax leaving a portion of the rear of the obstruction untouched.

RELATION OF THE EXPERIMENTS TO OBSERVED PHENOMENA IN ICE.

While the author was engaged upon these experiments Professor Chamberlin, in his annual address as president of the Geological Society of America (Recent Glacial Studies in Greenland, Bull. Geol. Soc. of Am., Vol. VI, p. 199) reported his observations of the previous summer on the glaciers of Greenland.

His observations tallied to such a remarkable extent with the results obtained in wax by the author that it has seemed important to consider the resemblance.

In comparing the two it must be recognized that the basal layer of dirty wax represents many débris layers and laminæ at the bottom of the ice and the lines above higher series of débris layers and laminæ. The seeming disparity in size of the wax experiments with the glaciers, need not be the cause of any hesitancy in comparing the results. Professor Chamberlin places the maximum limit of dirty ice at 150 feet of the basal part and thinks that it is "chiefly confined to the lower fifty or seventy-five feet." The experiments were supposed to represent only the basal portions of the ice and a ⅞ inch escarpment in a layer 6 inches thick is strictly comparable to an obstruction 10 to 20 feet high in 50 or 100 feet of the basal part of the ice.

In regard to the passage of the ice over low prominences, he says, p. 205, "In meeting obstacles in front, the basal beds have the habit of curving upward, carrying the débris with them." Again, p. 208, "*Behavior of Ice in passing over low Prominences:* Several excellent opportunities for observing the behavior of ice in passing over low embossments were offered. From the front of the embossment there originated laminæ which extended backwards with a graceful, arching curve, much like the profile of a drumlin. A portion of the ice remained between these curving laminations and the upper and rear portions of the embossment. After reaching a point in the rear of the embossment, the laminæ curved downward with increasing rapidity until well in the lee, when they turned about with a more or less sharp curve, or even angle, and ran backward to some point not far in the rear of the embossment, where they ended. The higher laminæ made the longest curves and had the sharpest angles in the lee of the embossment. It appears obvious that the ice in the lee of the embossment moved more slowly than that above; hence the doubling of the laminæ upon themselves. It appeared upon close inspection that some of the inthrust layers described above consisted in reality of very sharply reduplicated laminæ.

It seems, therefore, that this phenomenon grades insensibly into the preceding. A study of the laminæ not associated with embossments showed many signs of doubling upon themselves in a similar way. It appears, then, that there is a gradation from laminæ that simply suffered doubling up to layers that obviously sheared upon each other and produced manifest unconformity and overthrust." Compare the figures of this paper and Chamberlin's, Fig. 4, Pl. IV. Figs. 11 and 12, Pl. VIII.

The above might well serve as a description of the results of the experiments on the passage of wax over escarpments and the effect of drag. It might also serve as well to describe the formation of laminæ in wax, especially when supplemented by the following (p. 204): "The débris layers are not all uniform in their distribution. Often they have much regularity and persistence; often they thin out and disappear within a short distance; more often still they persist for a few rods and are replaced by adjoining layers which come in as these thin out. Thus a belt of layers has much persistence, while the constituent layers are freely entering and vanishing. Lenses of débris occasionally appear among the layers, and a doubling back of the layers upon themselves, giving a lenticular section is not uncommon." Compare this description with Figs. 7–10.

The action of the loops caused by drag in passing obstructions is not discussed by Professor Chamberlin, but Figs. 6, Pl. V, of his article is almost identical in its main features with the anterior part of Figs. 9–10 of the present experiments.

In discussing the origin of the stratification Professor Chamberlin brings forward the hypothesis of the shearing motion between superincumbent layers of ice, citing as proof, the observation of fluting in the interpolated laminæ of débris and the breaking of fallen blocks of ice along definite planes. "But," he says, p. 207, "the best evidence of the verity of shearing between ice-plates lies in the intrusion of the earthy material itself. I was fortunate enough unless I misinterpret, to observe the actual process of intrusion. The best illustration was found on the north side of a short lobe of the great ice-cap designated the

Gable glacier. Just back of the point of observation there was a large embossment of rock, which expressed itself at the surface of the ice by a beautiful half dome, like the Half Dome of the Yosemite. The other half of the dome was cut away, revealing the operations at the base within Here it was observed that the trains of débris, apparently rubbed from the surface of the embossment, were being carried out almost horizontally into the ice in its lee. Some of these were short, while others extended several rods into the ice. They were somewhat inclined downward, but the slope of the glacier being greater, they passed out into the body instead of following the base of the ice. At one point the overthrust reached such a degree as to carry the earthy layers obliquely almost across the thickness of the glacier, producing a pronounced unconformity. (Figs 9 and 10, Pl. VII., Chamberlin.) . . . The mode of operation seems to be this: When the ice is forced over a prominence it settles down a little in its lee, and is then protected somewhat from the thrust of the ice behind; the next ice that passes over, being prevented by the former portion from settling down at once, is thrust forward over it. To some extent this is accomplished by the bending and doubling of the layers, and to some extent by distinct shearing. At length, however, the first layer is compelled by the general friction to move somewhat forward, and in time to join the common moving mass, carrying the overthrust layer of débris between it and the ice layer above. The way is then open for a repetition of the process. This picture of the behavior of the ice is quite radically different from that entertained by the viscous hypothesis, in which the ice is supposed to flow down the lee side of a prominence, as if it were a liquid. The motive power here seems not so much gravitation pulling a fluent body forward as the thrust of a rigid body by a force in the rear."

The descriptive part of this would answer, especially in the first case cited, as a perfect description of the results of Experiment 5, Fig. 4*b*. But the explanation cannot be accepted as applying to the results produced in the experiments because they were obtained in warm wax, a viscous body, incapable of shear along

definite planes, at least under the very slow movement to which it was subjected. The phenomena may be explained fully as well by recourse to the drag of the bottom. The lower layers of the ice were retarded while the upper flowed over the obstruction and onto its rear face. It was there protected from further push as well as retarded, and the lower layers having meanwhile backed up against the front of the escarpment, overflowed and passed out into the ice in a horizontal line resulting from a stretching of the viscous body as seen in all the experiments. It is to be noted that while the general depression of a viscous mass is caused by the pull of gravitation, the motion at any one point is due to the motion of the mass behind it and is largely a shove, rather than a pull.

The result arrived at by Professor Chamberlin from his observations was that the ice was rigid in great part and moved along planes of shear between well individualized layers. He says, p. 212: "My observations seems adverse to anything which can be properly termed viscous fluency." And again, p. 213: "Everywhere the aspect of the ice was that of rigidity rather than viscous fluency. The rigidity, to be sure, did not prevent contortions and foldings of the laminations, such as take place in the crystalline rocks, but faulting and vein structures also occur, and there seems no more occasion to assume viscosity in the one case than in the other. Even if a certain measure of viscosity be admitted, it does not follow that viscosity was an essential agent in motion."

From the peculiarly perfect manner in which the results of the experiments in wax and the observed phenomena in the ice parallel each other, it seems that the obvervations of Professor Chamberlin may be interpreted in a slightly different manner and that his "certain measure of viscosity" may have afforded a very considerable part in the mechanics of the ice bottom. At least some method of movement must be admitted which will produce currents such as would be produced in a viscous body under like conditions. And this motion, it seems to me, cannot be produced by shearing alone.

RELATION OF THE CURRENTS TO THE SUBGLACIAL TOPOGRAPHY.

It seems from the above to be fairly well proven that differential currents, vertical and horizontal, do exist in the bottom portion of the ice, and recognizing their existence it is possible to attempt the explanation of certain features of subglacial topography. It can be shown that great drumlin-covered drift deposits lie in the lee of escarpments, or other irregularities of the surface, composed of hard rocks, over which the ice has just passed.

The upward currents produced at the front of an escarpment and extending over it in an arch have already been pointed out. The active portion of the ice bottom is undoubtedly in the region of the descending currents and the portion below the arch must be one of very slight activity. In speaking of drumlins Professor Chamberlin mentions this curve and says, p. 216: "I suspect that this is the true drumlinoid curve and that it represents the balance or the accommodation between the force of the overthrust of the over-riding ice on the one side and the friction and resistance of the ice and débris against the embossment on the other. I suspect that the progressive tendency in such a case is toward the accumulation of débris below the drumlinoid line, which was apparently a line of shearing, and that the result of such an accumulation would be a drumlin."

This idea was also entertained by the author and applied to the formation not only of drumlins but to the larger deposits of drift. It will be easily seen that in passing large escarpments the base of the proportionally large arch currents would be thrown into minor arching currents by minor irregularities on the escarpment. The large arches would have under them regions of relatively smaller ice motion with consequent deposition of débris; the point of descent of the current would determine regions of erosion. This action will be clearly seen by reference to the diagram, Fig. 11. A line was taken from Sodus Bay on Lake Ontario to a few miles south of Ithaca, N. Y., taking in the deepest part of Cayuga Lake. Upon this line is projected the extremes of elevation in surface a few miles to each side of it.

It will be seen how currents might rise from the bottom of Lake Ontario passing in an arch over the drift-covered region south of the lake and then descend to aid in the excavation of the bed of Cayuga Lake.

The minor irregularities of the Medina conglomerate, bordering this portion of the shore of Lake Ontario, produced minor and differential currents in bottom of the great arch and formed the drumlins. This diagram would apply with slight modifications of detail to a large majority of the known drumlin regions.

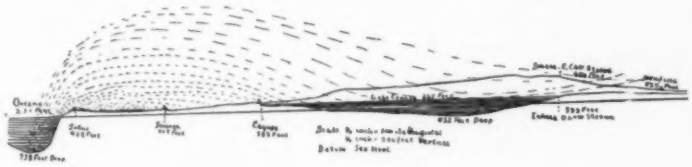


FIG. 11.

The formation of the elongated drumlins may find an explanation in the stretching out of the débris into the ice from the top of an obstruction. If toward the end of the glaciation the drift should become of sufficient thickness, it might in spots clog up under the ice and become sufficiently resistant to cause upward currents in the ice. Its face would be moulded to its steeper form by the minor currents which creep up the face of an escarpment or obstruction (Expt. 2, Fig. 2), and are perhaps responsible for the characteristic steeper slope of the face of all subglacial erosion forms. The currents of inthrust débris would arise from the heaps of débris and extend forward into the ice a short distance, while still under the arch of the currents they would gradually sink and build up the rear of the drumlin into the elongated form. The elongation and building up of the drumlin would tend to keep the currents from descending and would lengthen the arch till drumlins two miles long might be formed as noted in New York.

One other action must be noticed, namely, the moulding power of the ice currents upon a thick sheet of till. It has been

claimed by various authors that the formation of drumlins was due to the erosion of a thick sheet of till by differential currents in the ice bottom. If this hypothesis is a true one, the source of the currents is readily found in the passage of ice over escarpments and other irregularities. It seems that the presence of the arched currents with regions of relatively inactive ice below over drumlin regions must give the weight of evidence largely to the theory of deposition, though the points of descent of the currents were points of erosion, in all probability, and these must have had some influence in determining the exact location and form of the drumlins.

E. C. CASE.

GEOLOGICAL LABORATORY, CORNELL UNIVERSITY,
May, 1895.

ABSAROKITE–SHOSHONITE–BANAKITE SERIES.[1]

In the region of the Yellowstone National Park there are igneous rocks of a peculiar type which are associated with the normal andesites and basalts of the region, but which differ from them mineralogically and chemically, and deserves a special classification. The study of these rocks has been carried on in connection with that of all of the igneous rocks of this region, and the present paper is an abstract of a chapter prepared for the report of work done in the Yellowstone National Park by the division of the U. S. Geological Survey under the charge of Mr. Arnold Hague.

The rocks mentioned occur in a number of separate localities within this region, where it is apparent that their generic relations are with normal basalts and andesites, and in each locality the varieties having the peculiarities in question are genetically related to one another by differentiation. But all of these peculiar varieties in the region are not closely related to one another, for they are separate offshoots from distinct reservoirs of magma, and were probably produced by similar processes of differentiation. For purposes of systematic description they may be classified together in a series having certain chemical and mineralogical characteristics. They thus form classes of similar rocks (*i. e.*, like phases of differentiation), that belong to separate, but similar, families of rocks (*i. e.*, groups or series of genetically, hence generically, related differentiation products).

For the most part they are basaltic-looking rocks, occurring as lava flows and dikes, and less often as part of the basic volcanic breccia which constitutes the major portion of the volcanic mountains of the Absaroka Range. They are quite subordinate

[1] Published by permission of the Director of the U. S. Geological Survey.

in amount to the basalts and andesites. As surficial flows they are basaltic in character, being dark colored and heavy, with olivine among the phenocrysts in most cases. They are massive and compact or vesicular. They are porphyritic in some cases, but not noticeably so in others. They generally exhibit a semi-waxy luster that suggests the presence of nepheline, which however is not present. The luster is due to the alkali-feldspars in the groundmass. They are often dull greenish black owing to the serpentinization of olivine. As dikes they are basaltic in some cases, and phonolitic to trachytic in others, being gray in various shades, and having a somewhat waxy luster, due to alkali-feldspars. They are porphyritic or not in different cases, and range from aphanitic to phanerocrystalline.

They present quite a range of composition within limits, and form a series of varieties connected by gradual transitions. They could not be embraced by any one definition and must be divided into several classes.

The chief characteristics of the most basic class are the presence of abundant phenocrysts of olivine and augite, and the absence of phenocrysts of feldspar. The groundmass may be anything from a dark glass to an almost phanerocrystalline, light gray mass. It is oftener aphanitic and dark greenish gray. The phenocrysts are large and pronounced in many cases, but are quite small in others. Chemically they are low in silica, from 46 to 52 per cent.; low in alumina, from 9 to 12 per cent.; high in magnesia, from 8 to 13 per cent.; moderately high in alkalies, with potash higher than soda, except in one case. The molecular ratio of the alkalies to silica is .08 and .09. (See Table I). After the crystallization of abundant phenocrysts of olivine and augite the remainder of the magma, owing to low alumina and relatively high alkalies was so constituted that alkali-feldspathic minerals might crystallize out, which they did or not according to the conditions under which solidification took place.

The principal characteristics of the second class are the pres ence of phenocrysts of labradorite, augite and olivine, in a

groundmass that is usually dark greenish gray, with a semi-waxy luster; but which is sometimes glassy, or phanerocrystalline. The varieties range from those rich in olivine and augite, which with decreasing labradorite grade into rocks of the first class, to varieties poor in olivine and augite. Chemically they range from 50 to 56 per cent. of silica. Alumina is moderate to high, from 17 to 19.7 per cent. Lime and magnesia are moderate to low, the former from 8 to 4.3 per cent., the latter from 4.4 to 2.5 per cent. Alkalies are moderately high with potash comparatively high for rocks of this region with like amounts of silica; potash from 3.4 to 4.4 per cent.; soda from 3 to 3.9 per cent. The molecular ratio of alkalies to silica is .10 and .11. After the crystallization of phenocrysts of labradorite, olivine and augite, the remainder of the magma was rich in alkali-feldspathic material, which shows itself in the groundmass according to the circumstances of solidification.

Rocks corresponding chemically to both of these classes occur without megascopic phenocrysts, and in various phases of crystallization, consequently they differ from them not only in microstructure but in the minerals developed. They occur as lava flows and as dikes, but no special characteristics can be connected with either mode of occurrence, except that the more highly crystallized forms are found as dikes. Not all the dikes, however, are more crystalline than all the lava flows.

Rocks of the third class have been found mostly in dikes. These rocks are highly feldspathic, with smaller amount of ferromagesian minerals, chiefly biotite with subordinate augite. The phenocrysts are labradorite in a groundmass of alkali-feldspars. Chemically they have from 51 to 61 per cent. of silica; 16.7 to 19.6 alumina; 3.5 to 6 per cent. of lime; 1 to 4 per cent. of magnesia; 3.8 to 4.5 per cent. of soda, and 4.4 to 5.7 per cent. of potash. The ratio of alkalies to silica is .13 and .14. Since much of the lime and soda go into the phenocrysts of labradorite, the feldspathic groundmass is rich in potash, and is largely orthoclase. The rocks stand at the end of the series, where labradorite becomes the prevailing phenocryst, and

augite and olivine are more or less completely replaced by biotite.

The division of the series into three parts is for convenience. The classes will be described in the order just given under the names: *Absarokite*, *Shoshonite* and *Banakite*.

ABSAROKITE.

All of the rocks here classed as *absarokites* carry abundant phenocrysts of olivine and augite, except two that are included with them on grounds of chemical identity. They occur in the Absaroka range, and in other parts of the Yellowstone Park; at the north base of Sepulchre Mountain; upon Mirror Plateau; within the Crandall volcano; at Signal Point, Yellowstone Lake; at Two Ocean Pass, and in Ishawooa Canyon, and elsewhere. The chemical composition of five of these rocks is shown by the following analysis. Table I.[1]

TABLE I. CHEMICAL ANALYSES OF ABSAROKITES, YELLOWSTONE NATIONAL PARK AND VICINITY.

	1	2	3	4	5
SiO_2	47.28	48.95	48.36	51.76	49.71
TiO_2	.88	.49	1.18	.47	1.57
Al_2O_3	11.56	12.98	12.42	12.36	13.30
Fe_2O_3	3.52	3.63	5.25	4.88	4.41
FeO	5.71	4.68	2.48	4.60	3.37
MnO	.13	.13	.13	.11	.17
MgO	13.17	11.73	9.36	9.57	7.96
CaO	9.20	7.66	8.65	7.14	8.03
BaO	....	....	.29	....	.46
Na_2O	2.89–2.73	2.31	1.46	1.99	1.49
K_2O	2.22–2.17	3.96	3.97	3.83	4.81
P_2O_5	.59	.67	.84	.56	.66
Cl	.18	....	....	....	....
H_2O	2.96	3.16	5.54	3.05	4.07
	100.08	100.35	99.93	100.32	100.01
Less O for Cl	.04				
	100.04				

[1] Most of the analyses cited in this paper have already been published in the paper by the present writer on the Origin of Igneous Rocks. Phil. Soc. Washington. Bull. Vol. XII. pp. 89–214. Washington, 1892.

1. Leucite-absarokite, Ishawooa Canyon, Wyoming—analyzed by J. E. Whitfield.
2. Absarokite, dike at head of Lamar River—analyzed by L. G. Eakins.
3. Absarokite, dike south of Clark's Fork River—analyzed by L. G. Eakins.
4. Absarokite, lava flow, head of Raven Creek—analyzed by L. G. Eakins.
5. Absarokite, dike, divide east of Cache Creek—analyzed by L. G. Eakins.

The five analyses are arranged according to decreasing percentage of magnesia, the range being a little more than 5 per cent. The alumina increases, the range being less than 2 per cent. Potash increases through a range of 2.6 per cent., while soda and lime have a still smaller range. The second, third and fourth analyses are closely alike. The first and fifth are not so much alike that they might not be considered separately; the chief differences being in magnesia and alkalies. But they are related in other respects. They all exhibit considerable loss upon ignition, corresponding to the amount of hydration due to alteration, or to the presence of zeolitic minerals.

As already remarked the rocks differ somewhat in the mineral composition of the groundmass, as well as in its microstructure. That with the coarsest grain is the one whose chemical composition is given by the first analysis. It was not found in place, so that its exact mode of occurrence is not known, but it is probably an intrusive mass or dike in Ishawooa Canyon, Wyoming. It has already been described by Mr. Hague.[1] It consists of abundant phenocrysts of olivine and augite, 3^{mm} in diameter, and of a subordinate amount of gray crystalline groundmass. In thin section the olivine is colorless and free from inclusions. The augite is pale green, with high extinction angle, reaching 42°. It encloses some olivine and magnetite. The form of these phenocrysts is only partially idiomorphic, the outline being jagged in some cases; the reëntrant angles being occupied by small crystals of orthoclase, whose formation must have been at least contemporaneous with the crystallization of the margins of the olivine and augite. The groundmass consists of crystals of orthoclase and leucite, which are in part idiomorphic, although the mass is holo-

[1] HAGUE, A. Notes on the occurrence of a leucite rock in the Absaroka Range, Wyoming Territory, Am. Jour. Sci., Vol. XXXVIII., July, 1889.

crystalline, except for occasional possible remnants of glass base. There are also small irregularly shaped crystals of augite and olivine, besides magnetite and much apatite in long, slender needles. Orthoclase and leucite are not uniformly mingled, but are clustered in groups. The orthoclase crystals are rectangular prisms, twinned according to the Carlsbad law. Very rarely they contain minute cores of lime-soda-feldspar, with symmetrical extinction angles of 30°, corresponding to labradorite. The leucites are partly idiomorphic, partly allotriomorphic. In places they are decomposed to a zeolitic mineral. The other constituents of the rock are very fresh. Owing to the small amount of material collected no separations or partial analyses were attempted.

The rock, whose chemical composition is given by analysis 2, occurs as a four-foot dike on the divide between Lamar River and Crandall Creek. It is dark colored and aphanitic, with abundant phenocrysts of augite, 5 to 10^{mm} in diameter, and smaller ones of olivine. On the sides of the dike the rock is glassy and black. The body of the dike is holocrystalline and very fine grained when seen in thin section. The groundmass consists of indistinctly outlined, lath-shaped feldspars with low extinction angles, there is also an indistinct feldspathic mineral as cement, which is clouded. The lath-shaped feldspars appear to be in part, at least, orthoclase with minute prismatic cores of lime-soda-feldspars. Nothing resembling leucite is present. The feldspathic matrix is crowded with microscopic crystals of augite, magnetite and brown biotite in thin tablets. The groundmass of the glassy margin of the dike is brown glass with microlites of augite and some of lime-soda-feldspar. The augite phenocrysts are light green in thin section and are filled with irregularly shaped inclusions of crystalline groundmass containing rods of ilmenite. There are also inclusions of small olivines and magnetite. The olivine phenocrysts are idiomorphic and quite fresh, with small inclusions of magnetite and glass, and occasionally bays of groundmass.

The glassy groundmass of the margin of the dike is unlike

the groundmass of the central part in mineral composition. Biotite is not present, and the only feldspars are microlites of plagioclase, which may correspond to the prismatic cores in the small orthoclases of the central part of the dike.

When compared with the leucite-absarokite from Ishawooa Canyon it is found that the phenocrysts of olivine and augite are not so abundant as in that rock, while there is much more augite in the groundmass, besides abundant biotite. The microscopic feldspars are not so large and distinct, and leucite is wanting. Chemically the rock just described is richer in potash, with about the same soda. Alumina is slightly higher; and magnesia and lime slightly lower. Silica is a little higher. The high percentage of water indicates a hydrous silicate in the groundmass.

The rock, whose chemical composition is shown by analysis 3, forms a 3-foot dike on the high ridge south of Clark's Fork River, southeast of Index Peak. The rock corresponding to analysis 4 forms a surficial lava flow east of the head of Raven Creek on Mirror Plateau. Chemically they are almost identical, and nearly the same as the dike rock from the divide between Lamar River and Crandall Creek. They have slightly less magnesia, and the lava flow has 3.4 per cent. more silica than the dike rock. The dike rock is dark greenish gray, aphanitic, with small megascopic phenocrysts of augite, and occasional large crystals of quartz with augite shells. In thin section the few megascopic augites resemble those in the rock last described. All the other constituents may be considered as parts of the holocrystalline groundmass. They are abundant pale green augite, brown biotite and magnetite with a subordinate amount of feldspathic matrix. There are larger augites, colorless at the center and green at the margin, besides many small serpentinized olivines. The feldspar is partly lath-shaped orthoclase with prismatic cores of lime-soda-feldspars. They are often in radiating groups. There is also much cloudy microcryptocrystalline material with no definite form, except a frequent approach to the outline of an isometric mineral. These are often darker colored at the center, and suggest altered leucites. The large loss upon ignition and the pres-

ence of leucite in similar rocks in this region render this highly probable. Some parts of the rock contain what is undoubtedly analcite. The occasional large quartz crystals have the character of primary crystals. Their possible association with leucite is indicated, but no leucite has been actually observed in the rock.

This rock resembles the dike rock from the divide at the head of Lamar River in the general character of the groundmass, except that the phenocrysts of olivine and augite are almost microscopic, and may be considered as part of the groundmass. The ferromagnesian minerals are about the same in each, and the feldspathic components are obscure, with indications of alkaline character.

The rock of the lava flow at the head of Raven Creek is dark gray with abundant small megascopic phenocrysts of olivine and augite. In thin section these minerals resemble those in the rocks already described. The groundmass consists of small rectangular prisms of orthoclase, sometimes with minute cores of prismatic labradorite; besides abundant microscopic crystals of augite and magnetite, there is a little serpentine. The feldspars are distinctly crystallized and their character as orthoclase is unquestionable. They resemble the orthoclase in the leucite-absarokite from Ishawooa Canyon. No leucite, however, was observed in this rock. Only a very small part of the groundmass is lime-soda-feldspar. There is no biotite, and no analcite. Apatite occurs in delicate needles. The absence of biotite may be correlated with more pronounced orthoclase and abundant olivine; and the absence of leucite accords with the higher percentage of silica.

The rock, whose composition is shown by analysis 5, occurs as a narrow dike on the divide east of Cache Creek. It is brownish gray and aphanitic, without phenocrysts, but having minute brown pseudomorphs, presumably after olivine. There are occasional rounded grains of dark colored, crackled quartz, surrounded by a thin, green shell. In thin section the rock is fine grained and holocrystalline, consisting of

thin prisms of feldspar, frequently grouped in fan-like clusters. They are not distinctly striated, and are probably orthoclase. Others are lime-soda-feldspars, with low extinction angles, and some are irregularly bounded and are obscure. This matrix is crowded with idiomorphic crystals of pale green augite, dark brown biotite and magnetite. Some of the biotite crystals are long, narrow plates, resembling prisms of hornblende, for which mineral they were at first mistaken. There is considerable serpentine scattered through the rock.

Mineralogically this rock is very similar to the dike rock south of Clarks Fork River. Chemically, it is slightly higher in alumina and potash and lower in magnesia and lime. The high loss on ignition is probably due in this case to the serpentinization of the olivine.

There are other rocks of this class in the region, but they will not be described here. Transitional varieties between absarokite and normal basalts occur, as well as transitions to shoshonite.

SHOSHONITE.

The rocks classed as shoshonites are more numerous than the absarokites, and embrace a somewhat wider range of composition. They occupy the middle ground, as it were, in the series and pass by transitional varieties into absarokite, banakite and into normal basalt. They occur associated with absarokite, and consequently at the same localities: on the Lamar River, Mirror Plateau, Crandall Basin, at various localities in the Absaroka Range, and at Two Ocean Pass, one of the divides at the head of Shoshone River. From this locality the rock was first collected and identified as an orthoclase-bearing basalt. Shoshonites also occur in the northwestern portion of the Yellowstone Park. Most of these rocks are characterized by prominent phenocrysts of labradorite, together with those of augite and olivine. But some are without megascopic phenocrysts and are correlated with the porphyritic forms on chemical as well as mineralogical grounds. A small number are leucite-bearing.

The chemical composition of five of these rocks is given in Table II. The analyses are arranged so as to bring those most alike by the side of one another. The range of silica is 6 per cent. Alumina is moderately high. Magnesia, with a range

TABLE II. CHEMICAL ANALYSES OF SHOSHONITES, YELLOWSTONE NATIONAL PARK AND VICINITY.

	1	2	3	4	5
SiO_2	50.06	53.49	52.49	54.86	56.05
TiO_2	.51	.71	.81	.69	.98
Al_2O_3	17.00	17.19	17.89	17.28	19.70
Fe_2O_3	2.96	4.73	5.76	4.08	3.74
FeO	5.42	3.25	2.08	2.28	2.32
MnO	.14	.14	.09	.19	tr.
MgO	3.61	4.42	3.49	4.19	2.51
CaO	8.14	6.34	7.01	5.42	4.34
BaO	..	.06	.30	.37	..
Na_2O	3.53	3.23	3.18	3.94	3.29
K_2O	3.40	3.86	3.73	3.96	4.44
P_2O_5	.66	.43	.55	.48	.66
H_2O	4.85	2.17	2.63	2.16	1.86
	100.28	10.002	100.01	99.90	100.14

1. Shoshonite, lava sheet, Lamar River, south of Bison Peak; analyzed by L. G. Eakins.
2. Shoshonite, lava sheet, S. E. fork of Beaverdam Creek; analyzed by L. G. Eakins.
3. Leucite (?) -shoshonite, lava sheet, mountain east of Pyramid Peak; analyzed by L. G. Eakins.
4. Olivine-free shoshonite, dike N. E. of Indian Peak; analyzed by L. G. Eakins.
5. Shoshonite, lava sheet, Two Ocean Pass; analyzed by J. E. Whitfield.

of less than 2 per cent., is rather low for basic rocks. Lime, with a range of less than 4 per cent. is moderate. Soda is almost constant; and potash is relatively high, with a range of only 1 per cent. The loss upon ignition is comparatively high for all the rocks analyzed. As already mentioned, the mineralogical variation is from an abundance of olivine and augite to a paucity of them, with inverse variation in the feldspars. This accords with the variations in the chemical composition.

The rock of analysis 1 is a surficial lava on Lamar River, south of Bison Peak. It is dark gray, with a waxy luster, and has abundant phenocrysts of labradorite, augite and olivine; also some small amygdules of zeolite and calcite. In thin section it is holocrystalline, the groundmass consisting of lath-shaped lime-soda-feldspar and considerable orthoclase in zones surrounding the plagioclase microlites, and also in twinned prisms. There are besides augite, magnetite and a little serpentine. The phenocrysts of labradorite are twinned with very narrow lamellæ. Those of augite and olivine are like the phenocrysts of these minerals in absarokite.

The rock of analysis 2 forms a massive lava sheet on the southeast fork of Beaverdam Creek. It is dark purplish gray, with numerous phenocrysts of labradorite, augite and serpentinized olivine. A lighter colored variety carries porphyritical biotite and amygdules of zeolite. In thin section it is holocrystalline, and resembles the rock just described very closely, except that the olivine is serpentinized. The groundmass is similar to that of the former, and there is considerable orthoclase. In the variety with biotite there are cloudy patches of an isotropic mineral, which may be analcite. The lava sheet immediately overlying this one is similar to it in general appearance, but contains leucite, and is somewhat more alkaline (analysis 5, Table III), and will be described in connection with banakite.

The rock of analysis 3 is a surficial lava flow occurrring on the top of the table mountain east of Pyramid Peak. In general appearance it resembles the shoshonite from Lamar River south of Bison Peak (analysis 1), but the phenocrysts are fewer and smaller. The rock is holocrystalline and very fine-grained, with an abundance of microlites of augite and magnetite. The microscopic feldspars are lath-shaped crystals and allotriomorphic grains with low double-refraction. There are spots where minute grains of augite and magnetite are clustered together and are inclosed in a yellowish substance which is almost isotropic, and has the outline of leucite. These impure leucites are scattered

through the rock and are not very numerous. They are very minute and cannot be more definitely identified. The groundmass carries irregular patches of light brown mica, small phenocrysts of augite and of serpentinized olivine, and still fewer larger crystals of augite and olivine, but none of labradorite. The rock is a leucite-bearing modification of shoshonite magma, without noticeable difference in the chemical composition.

The rock of analysis 4 forms a narrow dike on the ridge northeast of Indian Peak, Crandall Basin. It is gray and aphanitic, with abundant small phenocrysts of augite and lime-soda-feldspar with rather low extinction angles. It is very fine grained and holocrystalline, consisting of indistinctly outlined feldspar microlites, in part alkaline with low double-refraction and no polysynthetic twinning. There is a subordinate amount of biotite in idiomorphic microlites, besides prisms of augite and grains of magnetite. Olivine is absent, in which respect it differs from other varieties of these rocks. Chemically it is very similar to the shoshonite from Beaverdam Creek (analysis 2).

The rock of analysis 5 is the uppermost of five lava sheets that overlie one another at Two Ocean Pass. It is dark gray, with a waxy luster, and carries scattered phenocrysts of feldspar and serpentinized olivine. In thin section the rock is seen to be holocrystalline; the groundmass consisting of orthoclase in idiomorphic and also in allotriomorphic crystals, with much magnetite and augite, and some chlorite or serpentine, besides red-brown biotite, and hairlike needles of apatite. There are also comparatively large, but microscopic, dusted apatites among the phenocrysts, showing this mineral in two generations, or periods of crystallization. Some of these apatites are enclosed in olivine, which is completely serpentinized. The feldspar phenocrysts are labradorite, with highly developed polysynthetic twinning. In the rock of the second sheet at this place the feldspar phenocrysts are labradorite-bytownite, being decidedly basic with high extinction angles, and relatively strong double-refraction. The groundmass is like that of the overlying shoshonite, just described, except that the orthoclase crystals sometimes have a

small nucleus of lime-soda-feldspar. Another one of these five sheets of lava is shoshonite like the last two mentioned.

BANAKITE.

The most feldspathic rocks of this series, which occur as dikes associated with dikes of shoshonite and absarokite, are not so numerous, although more of them have been analyzed. They occur in Crandall Basin, in Ishawooa Canyon and near the head of Stinkingwater River. A leucite-bearing variety forms a lava sheet near Beaverdam Creek. Their chemical composition is shown by the analyses in Table III.

TABLE III. CHEMICAL ANALYSES OF BANAKITES. YELLOWSTONE NATIONAL PARK AND VICINITY.

	1	2	3	4	5	6	7
SiO_2	51.82	52.63	51.46	52.33	52.93	57.29	60.89
TiO_2	.71	.81	.83	.71	.72	.72	.49
Al_2O_3	16.75	16.87	18.32	18.70	19.67	18.45	17.14
Fe_2O_3	4.56	4.52	4.61	4.95	3.07	4.38	3.32
FeO	3.36	3.11	2.71	1.83	3.50	1.20	.95
MnO	.23	.10	.17	.03	.15	tr.	.09
MgO	4.03	3.69	2.91	2.69	2.88	2.08	1.16
CaO	4.94	4.77	6.03	4.71	4.69	3.57	3.58
BaO	.26	.29	....	....	.21	....	....
Na_2O	3.91	3.86	4.11	4.51	4.20	4.43	4.54
K_2O	5.02	5.17	4.48	5.45	4.75	5.43	5.71
P_2O_5	.52	.63	.86	.81	.59	.46	.27
NiO	....	....	....	.14	....	.12	.19
H_2O	3.97	3.65	3.89	3.45	2.73	2.18	1.61
	100.08	100.10	100.38	100.31	100.09	100.31	99.94

1. Banakite, dike, head of Lamar River, analyzed by L. G. Eakins.
2. Banakite, dike, Hoodoo Mountain, analyzed by L. G. Eakins.
3. Banakite, dike, Ishawooa Canyon, analyzed by L. G. Eakins.
4. Banakite, dike, near head of Stinkingwater River, analyzed by W. H. Melville.
5. Leucite-banakite, lava sheet, southeast fork of Beaverdam Creek, analyzed by L. G. Eakins.
6. Quartz-banakite, dike, near head of Stinkingwater River, analyzed by W. H. Melville.
7. Quartz-banakite, dike, near head of Stinkingwater River, analyzed by W. H. Melville.

The rocks of analyses 1 and 2 form dikes; the first occurring on the divide between Lamar River and Crandall Creek, and the second on the south slope of Hoodoo Mountain. The two dikes trend in the same direction and are possibly one continuous body. The rocks are alike chemically and mineralogically and may be described together. They are light gray and aphanitic, with a waxy luster. There are prominent phenocrysts of augite and rusted spots of serpentinized olivine, but none of feldspar. In the rock from Hoodoo Mountain there are amygdules of white stellate zeolite. In thin section the rocks are seen to be holocrystalline with more feldspar than ferromagnesian minerals. The feldspars are in part lath-shaped, in part tabular. They are simple twins, and are orthoclase with kernels of plagioclase which is mostly altered, the centers of the crystals being decomposed in many cases. There is considerable serpentine scattered through the rock. The ferromagnesian minerals are augite, biotite, magnetite, with some ilmenite in rod-like shapes. Apatite occurs in needles. There is considerable analcite, which partly occupies former cavities or cracks, and partly has outlines suggesting former isometric minerals. The dike on the divide at the head of Lamar River is immediately alongside of the dike of absarokite whose chemical composition is given by analysis 2 of Table I.

The rock of analysis 3 is quite similar to those just described but is still more feldspathic. It forms a dike in the Ishawooa Canyon. It is dark gray and waxy looking with tabular phenocrysts of feldspar and many smaller ones. It is holocrystalline, and consists of abundant lath-shaped twins of orthoclase having a rectangular kernel of labradorite, whose symmetrical extinction angles correspond to a composition of $An_3\ Ab_2$. There is an isotropic cement between the feldspars which may be analcite or sodalite. Biotite and augite are abundant in small crystals, besides magnetite and a little serpentine, which appears to have been derived from small olivines. The phenocrysts are labrodorite ($An_2\ Ab_3$), some of which have borders of orthoclase. Sodalite is possibly present among the phenocrysts.

The rock of analysis 4 is closely related to the last. It forms a dike near the head of Stinkingwater River. It carries more phenocrysts of serpentinized olivine, and is coarser grained, though still microcrystalline. The feldspars are more altered and less distinct. The mineral-composition is like the last rock described, but a few of the augites are bright green, indicating an approach to aegerite-augite.

The rock of analysis 5 is a leucite-bearing variety of banakite, already mentioned as forming a massive surficial lava flow immediately overlying the shoshonite whose chemical composition is given by analysis 2 of Table II., and which occurs on the southeast fork of Beaverdam Creek. Its chemical composition is but slightly different from that of the rock last described (analysis 4). The rock is dark gray with a somewhat waxy luster. It carries small phenocrysts of feldspar, serpentinized olivine and a few of augite. It is holocrystalline with a groundmass of microscopic leucites and unstriated feldspars which appear to be orthoclase, but may be plagioclase with low angle of extinction. There are also microscopic augites and magnetite, and some serpentine, besides a few patches of light brown mica. The phenocrysts are labradorite, serpentinized olivine and fewer augites, magnetites and stout apatites. The crystals of leucite have the characteristic form and inclusions, and in places are somewhat altered. This rock grades into denser, finer grained forms, and also into vesicular forms, which have the same mineral composition as the more crystalline part of the mass. Mineralogically the rock is more suggestive of shoshonite than of banakite, owing to the paucity of biotite and more numerous olivines. But the amount of ferromagnesian minerals is smaller than in shoshonite, and the proportion of alkaline-feldspathic minerals greater, which corresponds to the chemical composition.

The rocks of analyses 6 and 7 belong to this series both mineralogically and chemically, but are somewhat more siliceous, having 5 to 9 per cent. more silica. They might properly be given specific names, but at present we prefer to class them with

banakite, under the name of *quartz-banakite*, the amount of quartz however being very small.

The two rocks analyzed are closely alike in alkalies and lime, but the first one is lower in silica and slightly higher in alumina, iron oxide and magnesia. They differ somewhat in mineral composition, though both are characterized by abundant feldspar and biotite.

The first one (analysis 6) is a gray rock, distinctly crystalline with a few megascopic crystals of feldspar and mica. It is holocrystalline, and is composed of lath-shaped, rectangular and allotriomorphic feldspars, with considerable brown biotite, besides magnetite and a little augite, partly decomposed. There is a very little quartz and calcite. The central portion of the crystals of feldspar is lime-soda-feldspar, in some cases labradorite. The marginal portion is orthoclase which forms a considerable part of the crystal, but is subordinate in amount to the plagioclase.

The second rock (analysis 7) is light-gray with numerous small tabular feldspars and some large ones, besides a few phenocrysts of biotite. The rock is holocrystalline and nearly panidiomorphic, the feldspars of the groundmass being in small, rectangular to lath-shaped crystals with fluidal arrangement. The groundmass also contains a small amount of biotite, very little magnetite and augite, and some colorless apatite. The feldspar phenocrysts are labradorite, while the feldspar of the groundmass is mainly orthoclase with kernels of fresh feldspar that has the optical characters of oligoclase. There is very little quartz and a little chlorite or serpentine.

The mineralogical analogy between banakite and shoshonite is chiefly in the association of phenocrysts of labradorite with microlites of orthoclase. Biotite and augite occur in some rocks of both classes, while olivine is present in one variety of banakite, and is common to most shoshonites. These banakites are not properly minettes on account of the prominence of labradorite, and they differ from kersantites by the presence of orthoclase in the groundmass. They bear the same relation to kersantite that shoshonite bears to normal basalt. They are the

highly feldspathic modifications of shoshonite magma, and are complementary to absarokite, which represents the least feldspathic modification of the same magma.

A comparison of the chemical analyses of the rocks of this series, besides making evident the relationships already noted, also shows what mineralogical differences may obtain for rocks of nearly the same chemical composition. Some of these differences have already been described in the case of the leucite-bearing varieties. Other differences may be mentioned. Comparing the shoshonite lava flow from the south base of Bison Peak (analysis 1, Table II.) with the banakite dike rock from Ishawooa Canyon (analysis 3, Table III.), we find in the first, abundant phenocrysts of labradorite, augite, and olivine; while in the second, numerous phenocrysts of labradorite, but few and small ones of augite and olivine. The groundmass of the first shows much less orthoclase than that of the second, and no biotite, which abounds in the second. The latter contains what is probably analcite. The shoshonite lava flow from the southeast fork of Beaverdam Creek (analysis 2, Table II.), and the shoshonite dike rock from the ridge northeast of Indian Peak (analysis 4, Table II.), though nearly alike chemically, are quite unlike mineralogically. The first has abundant phenocrysts of labradorite, olivine and augite, while the second contains no olivine. The groundmass of the second contains some brown biotite, which may be secondary, while that of the second contains much biotite that is primary. In each pair of cases we find olivine more abundant in the surficial rock, and biotite more abundant in the dike rock, or these minerals may be entirely absent in one case or the other.

Similar rocks in neighboring regions.— Rocks almost identical with absarokite occur in the region of Bozeman, Montana, and have been described by Professor Merrill,[1] whose work was reviewed in the last number of this Journal.[2]

[1] MERRILL, G. P. Notes on some Eruptive Rocks from Gallatin, Jefferson and Madison counties, Montana. Proc. U. S. Nat. Mus., Vol. XVIII., pp. 637–673 (No. 1031), Washington, 1895.

[2] JOURNAL OF GEOLOGY, Vol. III., No. 7, p. 850, Chicago, 1895.

The chemical composition of these rocks is shown by the first four analyses in Table IV., taken from Professor Merrill s paper.

TABLE IV. CHEMICAL ANALYSES OF IGNEOUS ROCKS CORRESPONDING TO ABSAROKITE AND SHOSHONITE.

	1	2	3	4	5	6	7
SiO_2	46.90	49.13	50.82	51.65	50.03	52.33	54.15
TiO_2	.41	.42	.59	.55	.61	.14	....
Al_2O_3	10.17	9.05	11.44	13.89	14.08	15.09	18.92
Fe_2O_3	1.22	3.57	.25	2.70	2.92	4.31	6.79
FeO	5.17	5.05	8.94	4.80	6.11	4.03	
MnO	.10	.15	.19	.15	.08	.09	....
MgO	20.98	17.21	14.01	11.56	10.73	6.73	1.90
CaO	6.20	5.68	8.14	4.07	7.46	7.06	3.72
BaO	....	.05	.06	.19	.04	.07	....
Na_2O	1.16	2.01	1.79	2.99	1.46	3.14	5.47
K_2O	2.04	2.24	3.45	4.15	2.64	3.76	8.44
P_2O_5	.44	.38	.20	.21	.42	1.02	....
Cr_2O_3	.33	.39	.03	.80	tr.	....	....
SO_3	....	....	....	.19	....	....	Cl .42
H_2O at 110°	1.04	.84	....	1.30	....	2.68	....
Ign.	4.38	3.50	.58	1.89	3.70	....	not det.
	100,54	99.87	100.49	101.09	100.28	100.45	99.81

1. Fort Ellis, 2½ miles southeast of Bozeman, Montana—analyzed by T. M. Chatard
2. Bear Creek, Madison Valley, Montana—analyzed by T. M. Chatard.
3. South Boulder and Antelope Creek, Montana—analyzed by L. G. Eakins.
4. Cottonwood Creek, Montana—analyzed by T. M. Chatard.
5. Cottonwood Creek, " —analyzed by L. G. Eakins.
6. Cottonwood Creek, " —analyzed by L. G. Eakins.
7. Cottonwood Creek, " —analyzed by G. P. Merrill.

The variability of these rocks within certain limits is evident; the greatest range being in magnesia. As a class they are characterized by low silica and alumina, high magnesia, comparatively high alkalies, with much potash. The rock of the fifth analysis is a transitional variety, between absarokite and normal basalt. The sixth analysis is from a rock corresponding somewhat to shoshonite, in alkalies, but slightly lower in alumina,

and higher in lime and magnesia. It is associated with the rocks of analyses 4 and 5. It has nearly the chemical composition of the rock called yogoite by Pirsson. Associated with the absarokites in several places are highly feldspathic rocks, richer in alkalies than the banakite of the Yellowstone Park. The chemical composition of one of them is shown by analysis 7, of Table IV. They are undoubtedly complementary products of differentiation.

In the Highwood and Little Belt Mountains of Montana there are rocks almost the same as absarokite in chemical composition, but coarsely crystalline. They have been described by Weed and Pirsson,[1] the account of the rocks of Yogo Peak having just been published. The chemical composition of the rocks of Yogo Peak and those of the two rocks of Square Butte, Highwood Mountains, is shown by the analyses in Table V. taken from the articles cited.

Pirsson states that the three rocks from Yogo Peak grade into one another, and are facies of one mass, whose variations are the result of differentation. They are granular crystalline, and consist essentially of orthoclase and augite in different proportions, and with subordinate amounts of plagioclase, biotite, magnetite; and in the syenite, hornblende; and in shonkinite, olivine, besides accessory minerals. In the syenite orthoclase exceeds augite, in yogoite orthoclase equals augite, and in shonkinite augite exceeds orthoclase. Chemically the series is characterized by comparatively low alumina, with relatively high potash, which is nearly constant. The sum of the alkalies decreases with decrease of silica and alumina. Magnesia and lime are fairly high. In the two rocks of Square Butte the shonkinite is like that of Yogo Peak, but alumina and alkalies are somewhat lower, and magnesia and lime higher. The syenite of Square Butte, the complementary rock with shonkinite, is high in alumina and alkalies, and very low in magnesia and lime,

[1] WEED, W. H. and PIRSSON, L.V., Highwood Mountains of Montana. Bull. Geol. Soc. America. Vol. VI., pp. 389-422. Rochester, 1895. Reviewed in this JOURNAL. Vol. III., No, 7, p. 851; also Igneous Rocks of Yogo Peak, Montana. Am. JOUR. Sci., Vol., L., No. 300. Dec. 1895. pp. 467–479.

with very high potash. In these two cases we find shonkinites as extreme forms of differentations in connection with syenitic rocks quite different from one another in chemical composition, one being comparatively low in alumina and the other high, the sum of the alkalies in one case being 8.85 per cent., and in the other 12.74 per cent. In each instance the associated rocks are facies of one igneous mass.

TABLE V. CHEMICAL ANALYSES OF IGNEOUS ROCKS FROM YOGO PEAK AND SQUARE BUTTE, MONTANA.

	Yogo Peak.			Square Butte.	
	1	2	3	4	5
SiO_2	61.65	54.42	48.98	46.73	56.45
TiO_2	.56	.80	1.44	.78	.29
Al_2O_3	15.07	14.28	12.29	10.05	20.08
Fe_2O_3	2.03	3.32	2.88	3.53	1.31
FeO	2.25	4.13	5.77	8.20	4.39
MnO	.09	.10	.08	.28	.09
MgO	3.67	6.12	9.19	9.68	.63
CaO	4.61	7.72	9.65	13.22	2.14
BaO	.27	.32	.43	....	....
Na_2O	4.35	3.44	2.22	1.81	5.61
K_2O	4.50	4.22	4.96	3.76	7.13
P_2O_5	.33	.59	.98	1.51	.13
Cr_2O_3	tr.	tr.	tr.	....	....
SrO	.10	.13	.08	....	....
Li_2O	tr.	tr.	tr.	tr.	....
Fl	....	....	.22	Cl .18	.43
H_2O at 110°	.26	.22	.26	1.24	1.77
H_2O above 110°	.41	.38	.56		
	100.15	100.19	99.99	100.97	100.45
			O=Fl .08	O=Cl .04	.10
			99.91	100.93	100.35

1. Syenite, Yogo Peak, analyzed by W. F. Hillebrand.
2. Yogoite, Yogo Peak, analyzed by W. F. Hillebrand.
3. Shonkinite, Yogo Peak, analyzed by W. F. Hillebrand.
4. Shonkinite, Square Butte, analyzed by L. V. Pirsson.
5. Sodalite-syenite, Square Butte, analyzed by W. H. Melville.

In his account of the rocks of the grorudite-tinguaite series,[1] Professor Brögger describes a series of igneous rocks occurring as dikes that are characterized by mineralogical and chemical peculiarities, which distinguish them from all other rocks in the Christiania region, and which warrant their being separated into distinct classes. These have been named grorudite and sölvsbergite, the third member of the series being tinguaite. Between these classes are transitional varieties. The rocks of this series grade through mineralogical and chemical transitions into other rocks belonging to different series, such as laurvikite, laurdalite, nordmarkite and soda-granite. They represent a series of particular phases of differentiation of genetically related magmas, as in the case of the series described from the Yellowstone Park.

The chemical composition of the rocks in the grorudite-tinguaite series, as given by Brögger, is shown in Table VI. The whole series is more siliceous than those we have been considering, the range of silica being from 56.58 to 74.35 per cent. Some of the marked characteristics of this series are the strong decrease in alumina with increase of silica; also the corresponding increase in ferric oxide; the relatively high percentage of alkalies which increase with alumina, soda being greater than potash. Magnesia and lime are very low. The mineral characteristics are equally marked.

The consistent minerals are potash-feldspar and soda-feldspar, with ægerite (or alkaline hornblende) with quartz in some cases, without it in others, and with nepheline in others. Plagioclase is entirely wanting, and mica and hornblende are generally scarce. The chemical character of the series is distinctly different from that of the series of rocks just described from Yellowstone Park and Montana. A comparison of these series shows to what extent the products of differentiation in various regions may differ from one another, the laws of variation being quite opposite sometimes. Hence natural series of rocks, which may be genetically related, may traverse any scheme of sys-

[1] Brögger, W. C. Die Eruptivgesteine des Kristianiagebietes. 1. Die Gesteine der Grorudit-Tinguaite-Serie. Kristiania, 1894.

TABLE VI. CHEMICAL ANALYSES OF GRORUDITE, SÖLVSBERGITE, TINGUAITE.

	1	2	3	4	5	6	7	8
SiO_2	74.35	70.15	71.35	68.95	64.92	62.70	58.90	56.58
$TiO_2(+ZrO_2)$....	.65	.50	.35	tr.	.92	.40	....
Al_2O_3	8.37	10.60	12.21	14.00	16.30	16.40	17.70	19.89
Fe_2O_3	5.84	5.77	4.53	2.12	3.62	3.34	3.94	3.18
FeO	1.00	1.74	1.14	3.56	.84	2.35	2.37	.56
MnO	.22	.52	.78	.55	.40	tr.	.55	.47
MgO	.07	.35	tr.	.07	.22	.79	.54	.13
CaO	.45	.72	.22	.23	1.20	.95	1.05	1.10
Na_2O	4.51	5.30	6.51	5.45	6.62	7.13	7.39	10.72
K_2O	3.96	4.09	3.22	5.29	4.98	5.25	5.59	5.43
H_2O	.25	tr.	0.33	.05	.50	.70	1.90	1.77
	99.38	99.89	100.89	100.62	99.60	100.10	100.33	99.83

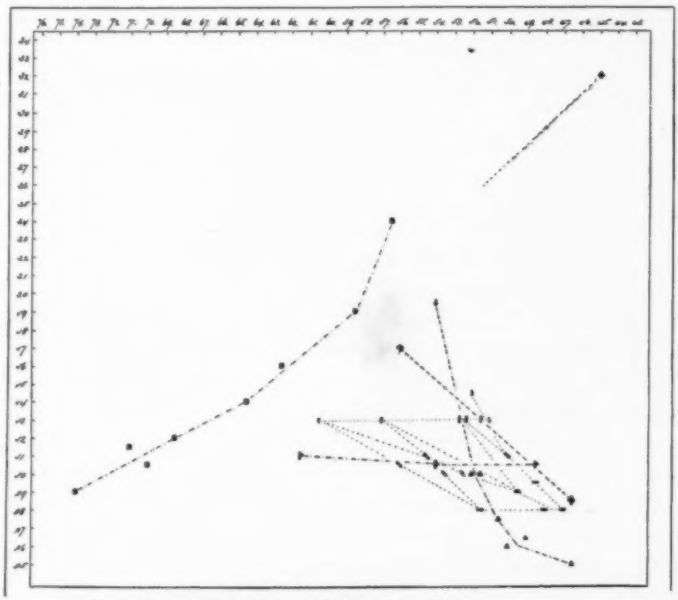
1. Grorudite, Varingskollen, Norway.
2. Grorudite, Grorud, "
3. Grorudite, Kallerud, "
4. Grorudite, Frön, "
5. Quartz-bearing Sölvsbergite, "
6. Nearly quartz-free Sölvsbergite, Lougenthal, Norway.
7. Nephelin-bearing Sölvsbergite, Tjose-Aklungen, Norway.
8. Tinguaite, Hedrum, Norway.

tematic classification of igneous rocks in various directions. This may be shown graphically as in the accompanying diagram, where the series of analyses are plotted so as to bring out the relation between the total alkalies and the silica in each case. The grounds for this method of comparison will not be gone into at this time, owing to lack of space, only the results can be given. The molecular proportion between the sum of the alkalies and silica in each case is expressed in parts of a hundred, which are used as ordinates. The silica percentages are used as abscissas, the highest being placed at the left. Hence the most silicious rocks are at the left hand end of the diagram, and those with the smallest ratio of alkalies to silica at the bottom. The rocks with least alkalies are at the lower right hand corner of the diagram. The location of the various rocks in such a scheme is indicated by different symbols.

DIAGRAM SHOWING THE RANGE IN ALKALI-SILICA RATIOS

$$\left(\frac{Na_2O + K_2O}{SiO_2}\right)$$

IN CERTAIN GENETICALLY RELATED SERIES OF IGNEOUS ROCKS.



- Grorudite-Tinguaite Series, Christiania region.
- Nepheline-Porphyry, Beemersville, N. J.
- Shonkinite-Sodalite-Syenite Series, Square Butte, Montana.
- Shonkinite-Yogoite-Syenite Series, Yogo Peak, Montana.
- Absarokite-Sodalite-Syenite Series, Bozeman District, Montana.
- Banakite, Shoshonite, Absarokite } Series, Yellowstone National Park.

The grorudite-tinguaite series traverses the diagram in an almost straight line, which rises steeply from the most siliceous end to the least siliceous, the alkali-silica ratio ranging from .09 to .24. The location of the so-called Sussexite, from Beemersville, Sussex county, N. J., which Brögger considers equivalent to a possible extreme form of differentiation belonging to this series, occurs in the diagram in direct line with the trend of the grorudite-tinguaite analyses. The alkali-silica ratio being .32.

The few analyses of the differentiation facies of the igneous cores at Square Butte and Yogo Peak are merely indications of the trend of these series. In fact at Square Butte, there are simply the two end results of highly advanced differentiation. The trend of the line connecting these extremes is almost at right angles to that of the grorudite-tinguaite series. The trend of the line connecting the three parts of the Yogo Peak mass is almost horizontal. The two analyses of shonkinite lie close together, but those of the complementary syenitic rocks are separated from one another by considerable space. Assuming that the sodalite-syenite and absarokites described by Professor Merrill are complementary rocks, as their association in the field and their analogy with the rocks of Square Butte indicate, we find a line connecting their possible series would be nearly vertical, as in the diagram. The analysis of the rocks of the absorakite-shoshonite-banakite series occupy a rather broad belt in the diagram, which lies between the extreme of the Yogo Peak and Square Butte series. The least siliceous absarokites lying very near shonkinite and the quartz-banakites lying between the syenites of these series. From the position of the analyses in the diagram it is evident that the absarokite-banakite series as here constituted is more comprehensive than either of the two above mentioned, which are in fact distinct series, since each is confined to a particular rock mass. But in the case of the dikes and lavas in the Yellowstone Park no such subdivision of these orthoclase-bearing, basic rocks could be established. Occurring as they do as a group of related lavas, having like geological relations, and analogous chemical and mineral compositions, they

must naturally be considered as a series variable in two principal directions chemically: in the ratio of alkalies to silica, and also in the silica percentages. The variations of the other chemical constituents are to some extent functions of these variables. In a region where highly differentiated igneous rocks occur as disconnected geological bodies in great numbers, it might always be possible to select some particular series of isolated rocks as a genetic series, from which a law of differentiation might be derived. But it would seem that the several instances of "laccolithic differentiation" described by Pirsson must be the surest basis upon which definite laws may be established. And on the other hand, anything like the frequent occurrence of differentiated lavas in a region must involve a multiplicity of lines of differentiation which cannot be disentangled, and which must of necessity be treated collectively. As Professor Brögger observes in the work already quoted the various members of the grorudite-tinguaite series in the Christiania region are mostly disconnected rock masses, and are probably related genetically with rocks differing slightly from them in chemical composition, so that members of a parallel series, differing in its general character from the one described, may be genetically more closely related to certain members of the first series, than to some members of the chemical series in which they may have been placed.

The question how far the genetic relationships between igneous rocks can be made to serve as a basis of classification is an open one. They certainly constitute the foundation of a genealogy of igneous rocks, but it may be doubted whether they can properly mark the lines along which a systematic classification can be established.

JOSEPH P. IDDINGS.

DISTRIBUTION OF GOLD DEPOSITS IN ALASKA.[1]

THE deposits hitherto worked on the Yukon River are stream gravels, and the region in which most work has been done thus far lies on the great river and its tributaries near the point at which it crosses the eastern boundary of the territory. Along the southern coast of Alaska there are several localities at which quartz mining is carried on, and some at which placers are in operation. A number of deposits exist along the coast in the region of Juneau. Of these much the most important and famous is the Treadwell mine. The Treadwell, on Douglass Island,[2] produces over half a million a year, from ore which averages only $2.50 to $3.00 per ton. Thanks to the enormous scale of the workings, more than half of the gross yield is net profit. The main country rock is a slate of sedimentary origin, and probably of Triassic age. It has been penetrated by a heavy dike of granite and two other intrusive masses. The last of these is a rock of basaltic character, and its eruption seems to have accompanied the mineralization. Both the granite and the slate were ruptured along a zone which is at some points several hundred feet in width, and the interstitial spaces have been filled with ore. In the granite the mass was in great part reduced to irregular fragments, and these have been decomposed and impregnated. In the slate the fractures mostly followed the cleavage, and the deposit there assumes the form of what I call a "stringer lead." The claims to the southward of the Treadwell are controlled by the same company, and are profitable, but the next claim to the northward is said to be too poor to pay.

Silver Bow Basin lies about three miles north of east from

[1]Note read before the Washington Geological Society, by Mr. George F. Becker.

[2]Dr. GEO. M. DAWSON wrote a paper on this mine in Amer. Geologist, Aug., 1889.

Juneau. A considerable number of small veins of rather rich ore occur on the southern side of this basin. Although the basin was formerly occupied by a large glacier, the diminished upper end of which is still visible from the locality, parts of the side are covered with rotten rock in place, carrying gold quartz seams and forming what I call a "saprolitic placer." After the retreat of the glacier the basin was occupied by a lake, and the lake beds are successfully worked for gold by the hydraulic process, a very unusual case. Sheep Creek basin is separated from Silver Bow basin by a divide, and the same series of quartz veins extends into it. Some fifty-five miles to the southeast of Juneau lies Sumdum, at which there is a very promising vein already yielding some bullion, although the property is only being developed. At Seward City, near Berner's Bay, about fifty miles northwest of Juneau, there are also veins which are extremely rich at some points, and are yielding gold. On Admiralty Island, at Funters Bay, about thirty miles from Juneau, there are promising veins on which it is expected that mining will be commenced next year. Near Sitka, especially along Silver Bay and in the country to the southeast of it, there are numerous veins some of which have yielded a little gold. Most of them seem rather low grade, and the development is insufficient to justify an opinion as to their future.

At Yakutat Bay, just to the eastward of Mt. St. Elias, there has been some beach mining, as there has also been along the west shore of Kadiak Island. The ease of working and the unlimited supply of sand make beach mining on the western coast of North America very attractive, but the capriciousness of the distribution of pay streaks, and the difficulty of saving the gold, commonly rob such undertakings of success. I am not aware that any notable profit has been made in a single case from beach mines, either in Alaska or to the southward. Nevertheless the amount of gold which occurs in this way is enormous. On Kadiak Island, in Uyak Bay, there are several promising looking gold quartz veins of a couple of feet in thickness. Prospecting is going on there, and should be more

actively prosecuted. On Turn-again arm at the head of Cook's Inlet, where Cook was turned back from his effort to find a "northwest passage," stream gravels are being worked. The only success was on Bear Creek, for some two miles, and I could not ascertain that the average results there were more than about $5.00 a man a day. I learn from Captain Hansen, of the mail steamer Dora, that richer gravel was discovered after I had left Cook's Inlet, near the head of Turn-again arm.

The island of Unga is in the Shumagin archipelago, about 1000 miles a little south of West from Sitka. Near Delaroff Bay, on this island, is the Apollo Consolidated mine, a highly interesting and an important deposit, which is now yielding at the rate of over $300,000 a year. The country rock is andesite, and the deposit occupies interstitial spaces in a crushed zone of this rock. The ore averages between $8.00 and $9.00 per ton, and a very large part of the gold is free, though heavy bunches of sulphurets are of frequent occurrence in it. This district, in which ore has been found at many points, bears a striking resemblance to Bodie, Cal.

On the island of Oonalaska auriferous quartz has been found, but thus far nothing like a mine has been discovered.

I was accompanied to the Alaskan coast, during the past summer, by Messrs. Wm. H. Dall and C. W. Purington. Mr. Dall took charge of the coal deposits and I of the gold. Our report is naturally not ready, but is expected to appear in the spring.

GEO. F. BECKER.

THE very unfortunate report of the death of Dr. Geo. M. Dawson, we are most happy to state, proves to be entirely unfounded. It seems that it arose from the error of a cable operator in substituting "D" for "L" in transmitting a notice of the death of Dr. George Lawson, of Halifax. The erroneous report received considerable currency in the English press and appeared in a part of an issue of *Nature*, but was corrected by a second cablegram before the edition was completed. The false report returned to this country, but the correction, as usually happens in such cases, did not keep equal pace with it. The erroneous announcement appeared in *Science*, accompanied by a biographical notice, and thence received currency in this country. This was duly corrected in a later issue of *Science*, but the happy information again fell far behind the sad news, in our case and in some others, and so we find ourselves among the latest and most unfortunate victims of a mistake, very slight in a phonic sense, but very grave in its import. It is an inexpressible pleasure, however, to know that it is a mistake. We offer to Dr. Dawson and his friends our profound apologies.

EDITORIAL.

For the second time in the brief history of the Journal of Geology, we are called upon to record the loss of a member of its editorial staff. And now, as before, it is one in the prime of life, in the midst of a brilliant career, and in the enjoyment of rare prospects, Dr. George M. Dawson. Less than a year ago, he was elevated to the directorship of the Geological Survey of Canada, a position which he had amply earned by a score or more years of markedly successful work on the geology of the Dominion. His "Geology and Resources of the 49th Parallel," prepared when he was yet a very young man, gave him a recognized place in the scientific world. It has been followed by a long list of papers of unusual merit. It is to Dr. Dawson especially that we are indebted for the geology of the northern cordilleras and the great northwestern plains beyond the national boundary. His studies lay along many lines, and the wide range of his abilities peculiarly fitted him for the multitude of questions that were presented in the exploration of his vast and varied field. We hope to present a more adequate notice of his work in a succeeding number. T. C. C.

***

In the very interesting experiments on ice motion, described by Mr. Case on previous pages of this number of the Journal, it may be worthy of note, that the force employed was localized and horizontal. In a glacier, if it be assumed to act as a viscous liquid, the force is distributive and primarily vertical. In so far as there is a horizontal component it is derived from the vertical. It is therefore never in excess of the vertical (momentum and the lag in local adjustment aside). In a perfect liquid it

is precisely equal. In a viscous liquid receiving additions above, the horizontal is necessarily less than the vertical force (except locally). A horizontal force greatly in excess of the vertical does not therefore closely imitate the agencies of glacial motion, if it be true that a glacier acts as a viscous liquid.

If a glacier be presumed to move by means of granular changes, the ratio of vertical and horizontal forces may still be essentially the same, for the granular action may be merely a mode of motion under gravity. If, however, the growth of the granules brings into play the forces of crystallization, it is conceivable that the ratio of vertical and horizontal forces may not remain the same. It may be conceived that the amount of crystalline force brought into action along any given line is somewhat correspondent to the number of granules lying in that line, or to the length of the line. If this be true, the axis of the glacier would represent the line of greatest force. Gravity would of course interpose its influence and the combined result would be merely a greater or less departure from the mode of action under gravity alone. Probably no one will doubt that gravity dominates the phenomenon.

The experiments of Mr. Case more nearly reproduce the conditions of this phase of the granulation hypothesis than those of the viscosity hypothesis.

It is obvious that the nature and mode of application of the forces employed are critically important in dealing with a substance on the border line between the solid and liquid states. It is quite possible to manipulate a liquid so that it shall deport itself like a solid, and conversely, to handle a solid so that it shall deport itself like a liquid. A solid may be made to flow, or seem to flow like a liquid, and a liquid may be made to shear or to seem rigid like a solid. In these cases it is the manipulation rather than the nature of the substance that gives expression to the result. A semi-solid is peculiarly sensitive to the mode of manipulation, and in experiments with bodies of this class the interpretation of results is quite as much to be guided

by the mode of manipulation as by the nature of the substance manipulated. The experiments of Mr. Case, therefore, only whet our interest to a keener edge. Is it the viscidity of the wax and the mode of thrust that gives the similitude to the phenomena of the Greenland glaciers? T. C. C.

***

THE beautiful investigations of Dr. O. Mügge, which have come to hand since the above was put in type, go straight to the heart of one phase of the subject, viz., the method of internal movement of ice crystals when deformed by an external force.[1] Prisms were cut from carefully formed ice in various directions to the principal crystallographic axis, *i. e.*, the optic axis of the crystal, particularly in directions parallel and transverse to it. These were tested by placing their ends on supports and weighting them in the center. In testing the transverse prisms the optic axis was first placed in a vertical position. The prisms sagged and their ends were drawn inward. Optical examination showed that the optic axis remained normal to the bent surface. Subsequent observations on surfaces fractured for the purpose showed striation and other indications that plates of the crystal parallel to the basal plane had *sheared* upon one another.

When similar prisms were placed so that these gliding planes stood on edge, *no appreciable result followed*, even though greater weights and longer times were employed.

When prisms cut parallel to the principal axis were tested, the gliding planes being transverse to the prism, the weight sunk sharply into the upper face of the prism, and a *corresponding protrusion appeared below*. As the process continued, the protrusion below kept closely parallel to the indentation above, both widening somewhat, until a section of the prism had been pushed entirely out. Optical examination showed that the optic axis remained parallel to itself throughout. The block remained transparent and free from fracture. The weight appeared to

[1] Uber die Plasticität der Eiskrystalle. Separat-Abdruck aus dem Neuen Jahrbuch fur Mineralogie, etc., 1895. Bd. II.

have simply slipped the plates over their neighbors, carrying the adjacent ones forward with them to some extent by dragging, but not visibly affecting the more remote ones.

If a prism be made up of square cards and placed on its side and a transverse force be applied, the result will illustrate the apparent method of movement within the ice crystal in this last case. If such a prism be pressed at right angles to the cards, it will illustrate the bending of the first case, and if the cards be placed on edge, they will illustrate the effectual resistance to deformation of the second case. Variations of temperature through 10°, were not found to produce notable differences of result.

Not to mention other significant points, the investigation seemed to warrant the important conclusion that ice crystals yield to deforming forces by the sliding or shearing of the crystalline layers at right angles to the principal axis. No analogy to the motion of a viscous fluid appeared. Dr Mügge had previously found a similar method of deformation in other minerals, including gypsum, stilbite and vivianite. In respect to its mode of internal motion, ice is therefore to be classed with these minerals rather than bodies properly called viscous.

From these trenchant experiments it would appear that there is a suggestive analogy between the shearing movement of the crystalline plates within the ice crystal and the shearing motion of the individualized layers of the Greenland (and presumably other) glaciers. The ulterior question of the source of motion in glaciers is not reached by these investigations, though they offer suggestions of the first importance. They seem, however, to cut at the roots of the viscosity hypothesis by showing that ice-deformation is not even analogous to the internal movement of a viscous body. The word *plasticity*, as a very general term indicating the yielding of solid bodies, may still be applied to ice, but is not the term viscosity already sufficiently burdened with duplicity to entitle it to relief from further service in this much battled field?

T. C. C.

BEGINNING with the first number of Vol. IV, the JOURNAL will present a series of four articles under the head of "Studies for Students," by Professor Van Hise, on (1) Movements of Rocks Under Deformation; (2) Analysis of Folds; (3) Cleavage and Fissility; (4) Joints and Faults. Dr. Van Hise has recently given these subjects very careful study, and his synopses will undoubtedly possess rare merit. C.

Reviews.

Mollusca and Crustacea of the Miocene Formations of New Jersey. By R. P. Whitfield. Monog. U. S. Geol. Surv. Vol. XXIV. (1894).

Previous to the publication of this monograph by Professor Whitfield, the fossils of the Miocene beds of New Jersey have never been systematically studied and recorded. A few of the most prominent species have been described here and there by different authors. Mr. F. B. Meek mentions only seventeen species from New Jersey in his list of Miocene fossils published in "Smithsonian Miscellaneous Contributions." In his "Tertiary Geology of the Eastern and Southern United States," Professor Heilprin enumerates twenty-seven species, seventeen of which he gives as peculiar to New Jersey. The same author, in an article on "The Miocene Mollusca of the State of New Jersey," enumerates thirty species, but later adds to this list from collections obtained from the marl pits at Shilo, giving fifty species from this one locality. The total number of species known up to 1887 was eighty-two.

In the present work one hundred and four species are recognized, thirty-six of them, so far as known, being peculiar to New Jersey. The author states, however, that there is no doubt that many more might be obtained were the beds more thoroughly examined and more localities visited.

A list of fourteen species of foraminifera are recorded, determined by Mr. Anthony Woodward of the American Museum of Natural History, obtained from a few ounces of marl from the interior of some of the shells.

The geological horizon of these New Jersey beds is considered by Professor Whitfield not to differ from that of the beds in Maryland, Virginia and the Carolinas, whether they be strictly Miocene or Mio-Pliocene as some are disposed to call them.

The fossils described are illustrated by twenty-four plates and are distributed as follows: *Brachiopoda*, 1 sp., *Lamellibranchiata*, 61 sp., *Gasteropoda*, 41 sp., and *Crustacea*, 1 sp. S. W.

AUTHORS' ABSTRACTS.

U. S. Geologic Atlas. Folio 11, Jackson, California, 1894.

This folio consists of two pages of text descriptive of the Gold Belt, concluding with a generalized section of the formations of the Gold Belt, four pages of text descriptive of the Jackson area, signed by H. W. Turner, geologist, and G. F. Becker, geologist in charge; a topographic map of the Jackson tract (scale 1:125000), a sheet showing the areal geology, and a third of structure sections.

The area covered by the folio embraces a portion of the foothills of the Sierra Nevada, chiefly in the counties of Amador and Calaveras, California. The area is drained by the Mokelumne and Calaveras rivers. The region is one of great economic importance, and comprises a portion of the rich belt of gold-quartz mines known as the Mother Lode. One of these mines, the Utica, at Angel's Camp, is said to be paying one million dollars yearly at the present time.

There are two distinct series of formations represented in this area. The Calaveras and Mariposa formation, of sedimentary origin, and the associated igneous rocks form an older, highly disturbed series, on which a later series rests with a marked unconformity. This later series represents the Tertiary and Pleistocene periods.

The Calaveras formation, of Carboniferous age, is composed of slates, quartzite, mica-schists, and limestone lenses, and contains frequent gold-quartz veins. The Mariposa formation, of Jurassic age, is largely made up of clay-slate. There are two main belts of this formation, and in the eastern one occur many of the gold-quartz mines of the Mother Lode.

The igneous rocks associated with the Calaveras and Mariposa formations are of considerable variety, but only three form considerable areas. These are serpentine, granite, and the porphyrites (old andesites) and their tuffs. The serpentine is undoubtedly an altered form of basic igneous rocks (pyroxenite and pridotite), and is intrusive. The granite is likewise intrusive, cutting through all the older rocks, except the Mariposa formation, and there is little doubt that it is later than this formation also, and in adjoining districts it invades the Mari-

posa slates as well. The porphyrites are largely altered forms of surface lavas and tuffs, resembling andesite and in part basalt, and these rocks have been folded and compressed along with the sediments of the Calaveras and Mariposa formations. The areas called amphibolite-schist on the geological map are chiefly metamorphic forms of these porphyrite-tuffs.

The formation of the later series, resting on these older rocks, that deserves most attention is called Auriferous gravel formation. These gravels which are found chiefly on the ridge-tops, were deposited in Neocene time by rivers. These old streams, as may be seen by inspecting the map, united into one trunk a little to the north of the Bear Mountains, and there found an outlet into the gulf that then filled the San Joaquin Valley. At many localities these old-river gravels have been profitably mined for gold. Forming a capping to the gravels are usually beds of volcanic material, chiefly andesite and rhyolite.

The Calaveras formation is of economic importance as containing frequent gold-quartz veins and lenses of limestone. Most of the latter are noted on the geological map.

The Mariposa formation affords a good roofing slate, but is chiefly remarkable as containing, in Amador county and in the north portion of Calaveras county, the quartz veins of the Mother Lode.

The amphibolite-schist belts contain copper deposits and gold-quartz veins. In the southern part of Calaveras county, at Angel's Camp, the Mother Lode lies to the east of the Mariposa slates and intersects a belt of amphibolite-schist.

In the granite of the West Point area are numerous gold-quartz veins, the ores of which contain a larger per cent. of sulphurets than the ores of the Mother Lode mines, and such ores are called base.

The serpentine areas contain chrome-iron deposits at numerous points.

The tuffs overlying the gravels at Mokelumne Hill, Valley Springs, and other points, have been found to make good building stone. Sandstone quarries are worked in the foothills in beds of Tertiary age, and the deposits of the same age near Ione afford large quantities of clay for pottery, and of coal.

U. S. Geologic Atlas, Folio 12, Estillville, Kentucky; Virginia; Tennessee, 1894.

This folio consists of five pages of text by M. R. Campbell, geologist, a topographic map of the district (scale 1:125,000), a sheet

showing the areal geology, another showing the economic geology, a third of structure sections, and a fourth giving a columnar section north of Clinch River and another south of that river.

The territory represented by the folio is located principally in southwestern Virginia, though the southern portion extends into Tennessee and the northwestern portion into Kentucky. Its area is 957 square miles, four-fifths of which is in the Appalachian Valley and one-fifth in the Cumberland coal basin.

The surface features are quite varied. In the Appalachian valley they consist of a succession of narrow ridges separated by equally narrow valleys, trending in a northeast and southwest direction. In the coal basin the ridges are less regular, but higher, reaching in two cases an elevation of over 4100 feet above the sea level.

The region is almost entirely within the drainage basin of the Tennessee River. The principal tributaries of this stream are Holston, Clinch, and Powell Rivers, each of which is a stream of considerable importance. The Kentucky portion of the territory is drained by the headwaters of the Cumberland River.

The geologic structure of the region is complicated. In the Appalachian Valley the rocks have been squeezed, in a northwest and southeast direction, until they have been forced into great folds. These are generally overturned toward the northwest, and have in many cases been compressed to such an extent that they have broken, allowing one limb of the fold to be thrust over the other. These faults are of frequent occurrence in this region. Sixteen or seventeen can be counted on the geologic map. In the coal basin the folding is less severe, and the result is a broad basin in which dips are prevailingly light, and in many places the rocks are horizontal.

The intense folding of the strata has brought to the surface all of the geologic formations from the Carboniferous to the Cambrian. On lithologic grounds these are divided into twenty-two separate and distinct formations. As a result of the original folding and subsequent erosion, these formations show at the surface in long, narrow outcrops of limestone, shale, or sandstone, which, in the various folds, are repeated over and over again. It is this repetition of the hard beds that gives rise to the numerous ridges which are such conspicuous features of Appalachian topography. In the coal basin the rocks are nearly horizontal, and hence they show in outcrop around the flanks of the mountains, or irregularly over the less rugged portions.

The mineral resources of this region are important, though at present but slightly developed. A belt of marble, varying considerably in composition and appearance, outcrops along the northern side of Clinch Mountain. Iron ore occurs in many parts of this territory, both in the form of limonite and in that of hematite. Red fossil ore is found in the Rockwood formation in the northern part of the region, and it is mined on Wallen Ridge south of Big Stone Gap. Coal is the principal mineral resource of this territory. It occurs in the structural basin north of Stone Mountain, and sparingly in the great arch of Powell Mountain east of High Knob. The coal-bearing rocks are approximately 5000 feet in thickness, and include many seams of workable coal. In the vicinity of Big Stone Gap the Imboden seam is the most important. It has been traced over a large area on the Virginia side of the basin, where it varies from 3 to 16 feet in thickness. On this side there are a number of other seams of good quality, ranging from 3 to 7 feet in thickness, which could be easily worked. The Kentucky portion has also many workable seams, but at present, owing to lack of transportation, no mining has been done on a commercial scale.

U. S. Geologic Atlas, Folio 13, Fredericksburg, Virginia; Maryland, 1894.

This folio consists of five and one-fourth pages of text, signed by N. H. Darton, geologist, and M. J. McGee, geologist in charge; a topographic map of the district (scale 1 : 125,000), and a sheet showing the areal geology.

The map represents an area of approximately 1000 square miles of the Coastal Plain region of northeastern Virginia and the southwestern corner of Charles county, Maryland. It includes, in Virginia, King George and the greater part of Caroline and Stafford counties, and adjoining portions of Spottsylvania, Essex, and Westmoreland counties. The city of Fredericksburg is near the center of the western margin of the area. The Potomac River crosses the northeastern corner of the area, and the Rappahannock River extends diagonally across its center on a northwest and southeast line. The headwaters of the Mattapony River are in its southwestern corner. Along these river valleys there are wide, low terraces capped by the Columbia formation, of Pleistocene age. The intervening areas are plateau remnants capped by Lafayette deposits, of supposed Pliocene age. The underlying formations are the Potomac, Pamunkey, and Chesapeake, which lie on an

east-sloping floor of crystalline rocks. This floor rises to the surface and constitutes hills of considerable height in the northwestern corner of the tract; eastward it is deeply buried under the Mesozoic and Tertiary sediments. The Potomac formation, which is the basal member of these sediments, consists of a heterogeneous series of sands and sandstones with intercalated clays. Much of the sand is arkosic, and consists of detritus of crystalline rocks. The Pamunkey formation, which overlies the Potomac unconformably, is the representative of the Eocene in this region. It consists in greater part of glauconitic marls. These marls are important fertilizers, and in some portions of the region have been used with excellent results. They are overlain unconformably by the Chesapeake formation, which is of Miocene age. It is characterized by fine sands, marls, and clays, portions of which consist largely of diatom remains. It is the same series that extends to Richmond, where its diatomaceous character was discovered many years ago, and to the northward through Maryland. It thickens rapidly eastward, and is nearly 1000 feet thick in the lower Chesapeake Bay district.

The crystalline rocks consist mainly of granites and gneiss and an infolded bed of slates, to which the name Quantico slates has been given. They are not of value for roofing slates, so far as is now known. They appear to be a continuation of the slates in the belts west of Richmond, in which lower Silurian fossils were discovered some time ago, but no fossils have been found in the area of the Fredericksburg sheet.

U. S. Geologic Atlas, Folio 14, Staunton, Virginia; West Virginia, 1894.

This folio consists of four pages of text, signed by N. H. Darton, geologist, and closing with a columnar section of the area; a topographic map (scale 1 : 125,000), a sheet showing the areal geology of the district, another showing the economic geology, and a third exhibiting structure sections.

The area represented is about 1000 square miles of central Appalachian Virginia. It comprises central and western Augusta county and portions of several adjacent counties. Staunton lies near the center of the eastern margin of the tract. About a third of the area is in the Great Valley of Virginia, and the remainder stretches halfway across to the Allegheny.

The geologic formations comprise members from the Shenandoah

limestones of the Great Valley to the Pocono sandstones of Lower Carboniferous age. There are also some small dikes of diabase in the northwestern corner of the area. The region is one in which relatively gentle folds predominate. There is an overthrust fault which extends along the western side of the Great Valley for some distance, and several other faults traverse the Shenandoah limestone.

The geologic classification does not differ materially from that outlined by W. B. Rogers, but geographic names have been applied to the formations. The name Shenandoah limestone has been selected for the great series of limestones of the valley. This series comprises several subdivisions, but they merge so gradually in the Staunton region that no attempt has been made to differentiate them on the map. The upper member contains a Trenton fauna, and it is thought that the basal beds of the series extends into the Cambrian, although no fossils have been discovered in them. Next, there is the representantive of the Utica and Hudson shales, which has been designated the Martinsburg shale. It is overlain by the Massanutten sandstones, which comprise the Oneida and Medina, in terms of the New York series. Next, there are the Rockwood formation and the Lewistown limestone, which include the formations between the Clinton and Lower Helderberg. The Oriskany and associated sediments are here represented by a stratigraphic unit to which the name Monterey sandstone has been given. The great series of Devonian strata lying above the Monterey has been divided into the Romney shale, Jennings formation, and Hampshire formation. As they are not sharply separated from each other the patterns by which they are represented on the map are merged over a narrow zone along their boundaries. Only a portion of the Pocono formation is included in the stratigraphic column in the region.

The principal economic resources are iron ores, which lie on a local unconformity between the Monterey sandstone and the Romney shale, and limestone for flux. Some of the limestones are suitable for marbles, and at many points lime is burned for local use. There are several thin, irregular beds of coal in the Pocono sandstone, but they are not of economic importance. Brick and pottery clays in the Great Valley complete the list of economic resources.

U. S. Geologic Atlas, Folio 15, Lassen Peak, California, 1895.

This folio consists of two pages of text by J. S. Diller, geologist, descriptive of the Lassen Peak district, supplemented by two pages, with illustrations (nine figures), devoted to recent volcanic activity; a

topographic map of the district, a sheet showing the areal geology, and another showing the economic geology.

The Lassen Peak district is situated in northern California, between the Sacramento Valley and the Great Basin, and adjoins the northern end of the Sierra Nevada. It is bounded by the 121st and 122d meridians and the 40th and 41st parallels, and contains an area of 3634.4 square miles.

Within the district there are three distinct topographic features. Beginning at the west, it includes (1) a small portion of the eastern border of the Sacramento Valley; (2) the Lassen Peak volcanic ridge; and (3) upon the east a portion of the Great Basin platform.

Twenty-two geological formations are shown upon the map. Thirteen of these were deposited by water as sedimentary rocks. The remaining nine are of igneous origin, and were erupted from the interior of the earth in a molten condition. Some of the sedimentary rocks, especially the younger ones, have not been materially changed since they were deposited; but others, such as the auriferous slates, have been greatly altered or metamorphosed, and contain veins of quartz and metalliferous deposits.

By far the most abundant rocks of the Lassen Peak district are those of igneous origin. The numerous volcanoes of the district have furnished a great variety of such rocks.

Beds of unaltered stratified rocks, none of which are older than the Cretaceous, are still nearly horizontal; although uplifted, they have not been compressed enough to produce folds. On the other hand, the auriferous slates have been thrown into a series of anticlines and synclines, and so greatly compressed as not only to close the folds, leaving the strata in many cases approximately vertical, but also to break and displace them along a series of thrust faults during the earth movements by which the mountains were produced.

Upon the economic map special attention is called to the distribution of auriferous slates, in which alone there is any probability of discovering valuable deposits of precious metals. These rocks are exposed in the southeastern and northwestern portions of the area mapped, and extend through under the lavas of the Lassen Peak district, from the Sierra Nevada to the Klamath Mountains of the Coast Range. The broad stretch of unaltered lavas about Lassen Peak does not contain any appreciable amount of precious metals, and may be wholly neglected by the prospector.

Among the auriferous slates seven formations have been distinguished, ranging in age from the Silurian to the Jurassic, inclusive. Of these the Cedar formation, of Triassic age, has been the most productive. By its disintegration it has furnished the gold for the placer mines of Indian Creek below Shoo Fly, of Soda Creek, Rush Creek, the north fork of Feather River, and Dutch Hill. The Savercool mine, by the north fork of Feather River, is on this belt, and active prospecting is going on at a number of points. Numerous copper deposits have been discovered in the Pit River region.

Intermingled with the auriferous slates there are eruptive rocks, such as diabase, porphyrite, peridotite, and diorite, which have much to do in determining the distribution of certain classes of ore bodies. The areas of eruptive rocks have been outlined, and it has been found that the most promising prospects of that region are located near the borders of these eruptive masses. The ore deposits may be in the auriferous slates or the eruptive rock, but in either case they are not far from the contact.

Traces of coal have been discovered in the Chico and Ione formations, but no deposits of considerable value are yet known in the region of Lassen Peak. The Tuscan tuff has furnished some excellent material for chimneys, hearths, and water coolers. The large deposit of diatom earth on Pit River, having a thickness of over one hundred feet and a length of several miles, is of economic importance for polishing, packing, making explosives, and other purposes.

U. S. Geologic Atlas, Folio 17, Marysville, California, 1895.

This folio consists of two pages of text descriptive of the Marysville tract, signed by Waldemar Lindgren and H. W. Turner, geologists, and G. F. Becker, geologist in charge; a topographic map (scale 1:125,000) of the tract, a sheet showing the areal geology, another showing the economic geology, and a third exhibiting structure sections.

Topography.—The Marysville tract includes the territory between the meridians 121° 20′ and 122° and the parallels 39° and 39° 30′, and contains 925 square miles. The tract is located near the center of the Sacramento Valley. The larger part of it is occupied by the alluvial plains of the Sacramento and Feather Rivers. The extreme northeastern corner includes the first rolling foothills of the Sierra Nevada. In the center of the tract rises the isolated mountain group of the Marysville Buttes.

General geology.—The alluvial lands consist of sands, clays, and gravels, deposited by the shifting currents of the streams. The foothill region of the northeastern corner is principally occupied by the gravels of Pleistocene and Neocene age. The area composed of the bedrock series of the Sierra Nevada is small and consists of diabase and porphyrite. The mountain group of the Marysville Buttes is an extinct volcano of probably late Neocene age, the internal structure of which is to a certain extent laid bare by erosion. The eruptive rocks of the buttes are andesites and rhyolites. In describing the structure of the group three parts may be distinguished: First, the central core of massive andesite and rhyolite; second, the upturned sedimentary rocks surrounding the massive core, evidently brought into their present position by the force of the ascending lavas; the sediments are of Eocene and Neocene age; third, the external ring of tuffs and breccias. The feature of greatest interest in connection with the Marysville Buttes is doubtless the presence of upturned sediments around the central core.

Economic geology.—The shore gravels in the northeastern corner contain some gold and have been washed superficially. Somewhat auriferous gravels are also found in the upturned sediments of the Marysville Buttes. Coal and natural gas have been found in small amounts in the Marysville Buttes.

Iowa Geological Survey. Vol. IV., Third Annual Report, 1894, with accompanying papers. SAMUEL CALVIN, State Geologist, Des Moines, 1895.

The fourth volume of the reports of the Iowa Geological Survey has been issued and distributed. So far as size and general make-up are concerned this volume is uniform with those previously issued. About fifteen pages are devoted to Administrative Reports and the remainder of the volume, which contains 467 pages altogether, is devoted to county geology. The geologists of Iowa have adopted the county as the areal unit for final geologic mapping and report. "The boundaries of counties are definitely located and generally known. The county is one of the organic units of civil government. Its inhabitants are bound together by common purposes, and have a common pride in its resources and in whatever promotes its welfare. Definite information

regarding the resources of his county as such has more interest to the ordinary intelligent citizen, ... than a report on an area embracing probably parts of several counties, though that area lend itself more naturally to scientific investigation, because limited by natural geographic features or distinguished by some peculiarities of geologic structure."

The first work of the Iowa geologists was necessarily in the nature of a general reconnoissance of the entire field. That work done, the energies of the Survey will hereafter be chiefly devoted to areal geology, the county in each case being the areal unit. The present volume contains reports on six counties: Allamakee, Linn, Van Buren, Keokuk, Mahaska and Montgomery. Reports on two counties, Lee and Des Moines, were included in Volume III. Geological maps of the several counties are published on a scale of one-half inch to the mile.

Geology of Allamakee County.—The volume proper begins with the geology of Allamakee county, by Samuel Calvin. This county is somewhat unique among the counties of Iowa in that it lies almost wholly within the *Driftless Area*. Its topography therefore is such as would be produced by the chemical and mechanical effects of destructive agents acting, for a somewhat limited period, on beds of limestones, sandstones and shales in a region standing from 600 to 700 feet above base level. The main streams have cut their channels to base level, and the dividing ridges have their sides deeply scarred and gashed by multitude of divaricating erosion channels indicative of greater or less progress in the work of bringing down the ridges to the same level. The tops of the ridges are regarded as co-incident with an old peneplain, and the difference in altitude between this peneplain and the base level of the present streams measures the amount of elevation that the region has suffered since the original peneplain was completed.

The geological formations of Allamakee county include the Saint Croix sandstones of Cambrian age, and the Oneota limestone, Saint Peter sandstone and Trenton and Galena limestones of the Lower Silurian. Overlying the indurated rocks are beds of residual clays and sands, while over nearly the whole county there is in addition a thin mantle of loess. A few erratic bowlders, probably overwash from the margin of the drift, are scattered over the southwestern part of the county. The report is embellished with a number of engravings that

are chiefly illustrative of the topographic features of the county. The economic products of the county justly receive a fair share of attention.

Geology of Linn County.—By WILLIAM HARMON NORTON. This paper contains several paragraphs of general interest. The Devonian series in the county is divided into the Cedar Valley stage and the Wapsipinicon stage. The latter embraces the Upper Davenport beds, equivalent to the Gyroceras beds of Calvin, and to the Upper Helderberg of Hall, and the Carboniferous of Barris; the Lower Davenport beds not before delimited; the Independence Shales described for the first time in natural sections, and a new basal terrane termed the Otis beds, whose characteristic fossil is *Spirifer Subumbonus*, Hall. Above the Le Claire, the highest member of the Upper Silurian hitherto recognized, were found two new formations, transition beds to the Devonian and named the Bertram and Coggan.

Of special interest to glacialists are the sections and maps showing the form and structure of the unique glacial hills of this region, the Paha. They are treated as loess-capped drumloid accretions of till.

Geology of Van Buren County.—By C. H. GORDON. Van Buren county lies on the southern border of the state with one county (Lee) lying between it and the Mississippi River. The main drainage is effected by the Des Moines River which cuts it diagonally from the northwest to the southeast. The surface consisted originally of a broad level plain having a gradual slope toward the southeast.

The indurated rocks belong entirely to the Carboniferous formations, including the Burlington, Keokuk, Saint Louis and Lower Coal Measure stages. The Burlington is represented by the upper chert beds, to which the name Montrose cherts is here given. The stratigraphy of the region is described in considerable detail, and errors of previous writers corrected. Some of the points of interest brought out in the paper are the following: a revision of the classification of the Keokuk and Saint Louis formation, and the plane of separation between these more satisfactorily defined (See Journal of Geology, Vol. III, No. 3, 1895); the origin of the ox-bow bend of the Des Moines (a topographic map of the area is given showing terraces up to 145 feet above the river); the erosion unconformity between the Lower Carboniferous and the Coal Measures.

Geology of Keokuk and Mahaska Counties.—By H. FOSTER BAIN. These two adjoining counties lie in the southeast central portion of

the state well to the eastern border of the coal field. In general geological features they are essentially similar. The indurated rocks include the Augusta and Saint Louis limestones and the Des Moines Coal Measures. The first two are, for this district, conformable. The erosion unconformity between the Saint Louis and the Des Moines is strikingly exemplified in Mahaska county at Corrier's Mill and Raven Cliff, and in Keokuk county at What Cheer. The Saint Louis in its full section shows from the top downwards (*a*) Pella beds, fossiliferous marls and bedded limestones, (*b*) Verdi beds irregularly alternating limestones and sandstones; and (*c*) Springvale beds, blue shales and earthy magnesian limestones. The Des Moines beds are made up largely of shales, with certain heavy sandstones and at least two coal horizons of which the lower is widespread and well opened up, and the upper is confined to a small portion of the Muchakinock Valley. The two counties are important coal producers, their aggregate tonnage for the year 1893 being 1,363,880 tons. The sandstones of the Coal Measures seem to mark local differences in sedimentation rather than a general horizon. There is evidence of some erosion during Coal Measure time. A series of slight parallel anticlinals cross the county from northeast to southwest.

The drift covers both counties in a sheet of very irregular thickness. It includes blue and yellow tills, local gravel and sand deposits, and an overlying silt or loess-like bed. The latter reaches no great thickness, but is an important source of material for clay-working industries, the total value of whose products for the year 1893 was $120,312. No distinct evidence of a well-marked forest bed is found and the correlation of the drift with that of other portions of the state is not attempted. Glacial striæ being S. 42° E., and a later set bearing S. 70° E. (magnetic), are found near Eddyville. The reports are illustrated by figures, half tones, cross sections and maps. On the map of Keokuk county a small area in Section 7 of Liberty Township, which the text shows to be Coal Measures, is by mistake colored as Saint Louis.

Geology of Montgomery County. — By E. H. LONSDALE. The exposed geological formations of Montgomery county represent three systems, the Pleistocene, the Cretaceous, and the Carboniferous. Alluvium, loess and till make up the Pleistocene, and the combined thickness of these three deposits amounts to nearly 100 feet. The Cretaceous, which consists for the most part of friable grits, con-

stitutes the southern extremity of the formation in Iowa. Although present as outliers, the maximum thickness of the deposit is as much as 115 feet. It is possible to consider these soft sandstones, with the associated clay shales and conglomerates of the same age, as Dakota—the Nishnabotna of White.

The Carboniferous is represented by only the Upper Coal Measures which here has a thickness of approximately 1500 feet; while the entire Upper Carboniferous is found to be about 2000 feet thick. To a depth of several hundred feet the Upper Coal Measures is made up almost exclusively of argillaceous shales and hard limestones. Occasional bituminous seams are prevalent, but heavy veins of coal are certainly not present within accessible depths and deep borings indicate that none occur even to the base of the Upper Carboniferous.

The district is supplied with various materials of great economic value. The eighteen-inch seam of coal found near the drainage level in the northwestern quarter of the county is being quite extensively mined. The clays from two of the geological horizons are being used in the manufacture of various marketable products. The limestone ledges are being quarried at several points and utilized as building-stone, but the rock is also suitable for lime-making. There is also an abundance of less important yet useful substances. The fertility of the loess soil is probably not inferior to that of any other locality in the state.

How Old is the Mississippi? By FRANCIS M. FULTZ. Proc. Iowa Acad. Sci., 1894. Vol. II., p. 39. Des Moines, 1895.

The evidence set forth goes to show that the present Mississippi drainage system existed as early as the beginning of the Upper Burlington epoch; and that, although interrupted by frequent and perhaps prolonged submergences, it nevertheless still remains practically the same.

Glacial Markings in Southeastern Iowa. By FRANCIS M. FULTZ. Proc. Iowa Acad. Sci., 1894. Des Moines, 1895. Pp. 213–217.

Recent discoveries of glacial scorings in southeastern Iowa are reported as follows: Near Kingston, in the northern part of Des Moines county, two patches within about half a mile of each other. The first presents a perfectly level surface, over one hundred feet in length and

from ten to twenty-five feet wide. The floor is covered with striations and grooves, all finely preserved. Four different sets can be easily determined. The grooves are straight and parallel; those from the latest series being fully an inch deep, while those from the earlier one are nearly obliterated. The trends given in the order of apparent age are as follows: 1. S. 30° 15′ E. 2. S. 64° E. 3. S. 60° 30′ E. 4. S. 72° 15′ E. Corrected for magnetic deviation. Aside from the direction of the striæ, all evidence points to a southeasterly flow of the ice sheet.

The second Kingston exposure lies on the brow of the bluff, facing the Mississippi flood plain, and extends for some distance down the face, descending at an angle of about 30°. There is but one set of markings, the trend being approximately 72° east of South. The bluff faces nearly due east.

In the Loftus quarry, four miles west of the city of Burlington, a large area was uncovered, showing both surface and lateral erosion. There was but one series of striæ, the direction being S. 75° E. The lateral erosion very strongly indicated the direction of ice flow to have been toward the Southeast.

Two other patches of scorings, about four miles northwest of Burlington, and located not more than forty rods apart, showed widely different trends. One was S. 33° E.; the other S. 73° E. Both surfaces were too badly weathered to furnish good corroborative evidence of direction of ice flow.

All the scorings above given are on the hard, compact limestone of the Upper Burlington formation, and are situated on or but a few miles back from the brow of the bluff that borders the old flood plain of the Mississippi.

Glacial markings previously reported from the vicinity of Burlington are as follows: By White, S. 15° E.; by Keyes, S. 63° E.; by Leverett, S. 65° E.

The Erosive Action of Ice. By G. E. CULVER. Trans. Wis. Acad. Sci., Vol. X., 1895.

This paper reviews briefly much of the literature relating to ice action, from the time of Ramsay to the present, and records some personal field observations bearing on the subject.

The author concludes that the erosive power of ice has been exag-

gerated in the past; that its transporting power has not been clearly discriminated from its eroding power; that it probably did not make rock basins, much less valleys; that in general its effect was to cut down prominences and fill depressions, and thus to lessen rather than to strengthen relief. He regards the drift as largely composed of material furnished by preglacial decay of northern rock. With this was mingled such fresh material as the ice could break from projecting points, and tear or wear from its bed.

Crystalline Limestones, Ophicalcites and Associated Schists of the Eastern Adirondacks. By J. F. KEMP. Bull. Geol. Soc. of Amer., VI., 241–262, 1895.

As study of the crystalline rocks in the eastern Adirondacks has progressed, it has become evident that in the gneissoid rocks on all sides of the Norian intrusions of anorthosites and gabbros, and extending well up between their ridges, crystalline, graphitic limestones, ophicalcites, and associated black hornblendic schists are met. Interlaminated with these are feldspathic gneisses, and occasionally graphitic quartz-schist, rich in sillimanite. The paper gives geological sections at Port Henry, and in western Moriah township, to show these relations. A most peculiar exposure in the Keene Valley, and well within the great anorthosite ridges, is also described, together with its intruded rocks — which are very similar to the Saxon granulites. In conclusion, the author briefly summarizes his conception of the rocks as a metamorphosed series of impure calcareous sediments.

The Stratigraphy of the Kansas Coal Measures; Division of Kansas Coal Measures; The Coal Fields of Kansas: By ERASMUS HAWORTH. *Kan. Univ. Quart.*, Vol. III., April 1, 1895, pp. 271-309, with two plates.

The articles with the above titles are summaries gleaned from chapters already prepared for Volume I. of the University Geological Survey of Kansas, which it is hoped will be completed during the year. Under the first heading is given a general description of the principal limestones and shale beds from the base of the Coal Measures to the Cottonwood Falls limestone, a vertical distance of 2500 feet or more. At the base of the column lie the heavy Cherokee shales, which are the principal coal-bearing shales of the state. Above these

are successive limestones and shales, the whole aggregating a total thickness of 2750 feet. But the author states (p. 272) that probably no one place could be found where the thickness would be quite so much.

Plate XX. represents this column. Plate XXI. is a semi-perspective map of the east end of the state, on which is shown outcroppings of the principal limestone formations.

The author divides the Kansas Coal Measures, in the second article, into two divisions, the Upper and the Lower, with the top of the Pleasanton shales serving for the division line. In the last article, the geologic and geographic position of each of the principal coal beds is given, with tables of analyses of the coals by Professor Bailey, and of the steam heating properties by Professor Blake.

Annual Report of the State Geologist of New Jersey, for 1894. Part I. Surface Geology: 149 pp. and 4 plates. By ROLLIN D. SALISBURY.

The titles of the several sections of the report are as follows: Sec. I. General Outline Sketch of the Drift Deposits of New Jersey North of the Moraine; Sec. II. The Glacial Striæ of New Jersey (with map); Sec. III. Changes in Drainage Effected by the Drift; Sec. IV. Postglacial Changes in Drift Area; Sec. V. Beacon Hill Formation; Sec. VI. Pensauken Formation; Sec. VII. Jamesburg Formation; Sec. VIII. Post-Jamesburg Formations; Sec. IX. Road Material; Sec. X. Explanation of Map of Surface Formations of Sheet 6, New Jersey Atlas.

In Section I., in addition to the matters implied in the title, details and sections (Pl. I) are given, showing the conditions under which the stratified drift of the valleys was deposited, and many details concerning the effect of stagnant ice on drift accumulations. In Section III., it is represented that while the ice effected many minor changes in the drainage in New Jersey, there were few of great extent outside the basin of the Passaic, and possibly the Raritan. The lakes of the state are classified with reference to the origin of their basins. In Section IV., emphasis is laid upon the trivial amount of erosion suffered by the northern part of the state since the drift was deposited. In Section V., the conclusion is reached that the Beacon Hill formation is of Miocene age; in Section VI., that the Pensauken is the equivalent of the Lafayette; and in Section VII., that the

Jamesburg formation corresponds with the Columbia. A twofold division of the Jamesburg is recognized, corresponding, in all probability, with the "high level" and "low level" Columbia of the south, as described by McGee and Darton. Sections (Pl. III.) are given showing the topographic and stratigraphic relation of the formations referred to in Sections V.–VIII. The report is accompanied by a map of the surface formations of the area covered by Sheet 6 (Basin of the Passaic and surroundings) of the New Jersey atlas, and Section X. is a brief statement intended to assist in an understanding of the map.

The Stone Industry in 1894. By WM. C. DAY. Sixteenth Ann. Report U. S. Geol. Survey, Part IV., 83 pp., 1895.

This report forms a part of the volume "Mineral Resources of the United States." It shows by numerous statistical tables the condition of the stone industry of the country in 1894 and compares this with former years. The various kinds of stone considered are included under the heads granite, marble, slate, sandstone, limestone and bluestone. The term granite is used in the broad commercial sense and includes rocks of igneous and crystalline siliceous character. The total value of the stone output in the United States in 1894 was a little more than $37,000,000 being a gain of about $3,500,000 over 1893.

The distribution of the active quarries is shown by states and counties. Many analyses and results of physical tests are recorded, and the present methods of quarrying, dressing and manufacturing the various kinds of stone are given in some detail. It is also shown that indications early in the present year point to 1895 as a period of increased activity in quarrying operations.

The Rocks of the Sierra Nevada. By H. W. TURNER. Fourteenth Ann. Report, U. S. Geol. Survey, pp. 435–495, 12 plates and 3 figs. 1895.

The following sedimentary terranes are recognized: Grizzly formation (Silurian), Calaveras formation (Lower Carboniferous), Robinson formation, chiefly tuffs (Upper Carboniferous), and Juras-Trias beds. All of the above terranes together with the associated igneous rocks were upheaved and folded at the close of the Jurassic. On their

upturned edges rests a series of late Cretaceous, Tertiary and Pleistocene sediments and lavas.

The igneous rocks are divided into an older series of Jura-Trias and Palæozoic age comprising diabase and porphyrite, gabbro, norite, peridotite and pyroxenite, granite, quartz-porphyrite, quartz-porphyry and diorite, and a later series comprising rhyolite, andesite and various basalts.

Results of Stream Measurements. By F. H. NEWELL. Fourteenth Ann. Report of the U. S. Geol. Survey, 60 pp. and 2 maps, 1895.

This paper gives the results of operations of the Division of Hydrography up to 1893, showing in concise form the mean monthly, minimum and maximum discharge of rivers in various parts of the United States. Most of the streams measured are in the West, where data of this character have especial value in considering the question of irrigation, and to a less extent that of water power. There are also given facts concerning some of the eastern streams. The most important feature of the paper, however, is to be found in the last part, in a discussion of the depth of run-off for the United States and the relation between mean annual rainfall and mean annual run-off. To illustrate, this small diagrammatic maps of average annual precipitation and run-off are given, and a diagram showing the general relationship between these. This discussion is necessarily general and preliminary to the preparation of more detailed maps which can be made only after observations have been carried on through many years.

Report on the Coosa Coal Field with Sections. By A. M. GIBSON, Assistant Geologist, Pp. 143, 1 plate. Geological Survey of Alabama. Montgomery, 1895.

This report deals with a coal field which, though long known, has not heretofore been adequately brought to public notice. This field is about sixty miles long by five to eight wide containing 345 square miles of productive area. It lies mainly in St. Clair and Shelby counties, the most southeastern division of the Alabama coal field. It lies in a synclinal fold of coal measures between the Cahaba and Coosa (Silurian) valleys. The reports shows that this field contains much undeveloped coal, embracing a large number of minable seams, some of which are of unusual thickness. The coal is generally very good, low in ash

and sulphur, hence well adapted for raising steam and forge work. Its coking qualities are specially commended. It is claimed that the well-known fact that the best coking coals in Pennsylvania and West Virginia lie toward the eastern side of this coal field is equally true of Alabama. A comparison of the cokes produced in these three regions seems to prove that this claim is well founded.

At present peculiar economic conditions confine active mining to two points. It is confidently hoped, however, that these conditions will be overcome in the near future, and that extensive developments will result from the information disseminated by this report.

The Structure of Monument Mountain in Great Barrington, Massachusetts. By T. NELSON DALE. Fourteenth Ann. Report of the U. S. Geol. Survey, pp. 557–65.

Following up some studies of the late Professor J. D. Dana, the author shows that this mountain is either of Cambrian age and separated from the Silurian schist mass of Lenox Mountain on the north by a zigzag fault, similar to that described in his other paper as occurring at Dorset Mountain, or else of Lower Silurian age with either a sharp fold or normal fault on its eastern side. The latter view involves a local change in the character of the Silurian sediments.

Since the publication of the paper the author has revisited the locality with Professors C. R. Van Hise and B. K. Emerson who regard the fault theory as the more probable one. The question then arises whether such a transverse fault would not necessitate a longitudinal fault on one or both sides of the mass.

On the Structure of the Ridge between the Taconic and Green Mountain Ranges in Vermont. By T. NELSON DALE. Fourteenth Ann. Report of the U. S. Geol. Survey, 1895.

A topographic and geologic map of four square miles of the ridge, sections, sketches and illustrations of clearage phenomena, "torsional grooving," Pteropod oölite, etc., are given. The ridge is a complex anticline of Lower Cambrian quartzite, etc., overlain by the Cambro-Silurian "Stockbridge Limestone" followed by the Lower Silurian "Berkshire schist," measuring 2000–3200 feet. This anticline is faulted by a double fracture letting down a block several hundred feet wide into the anticline to a depth of 1500 feet and in other places by a reverse

fault showing the Cambrian over the Silurian. The fault is twelve to eighteen miles long. In Danby the ridge is crossed by a zigzag E.-W. transverse reverse fault bringing the Cambrian to the level of the Silurian with a vertical displacement of 1450 feet, accounting for a large part of the height of Dorset Mountain.

Notes on the Stratigraphy of the Cambro-Silurian Rocks of Eastern Manitoba. D. B. DOWLING, B.A.Sc. Ottawa Naturalist, Vol. IX., No. 3.

Below the Hudson River shales, the limestones are provisionally divided into a lower and upper Mottled, with a dividing band of fine grained limestone holding cherty nodules. The basal member of the series is a soft sandstone with shaly partings grading downwards to a friable sandstone which may be correlated with the St. Peter's sandstone. The distribution of these divisions is discussed and shown on a sketch map. The thickness of the formation is estimated from exposures on Lake Winnipeg at 580 feet. This is compared with sections obtained from borings within the district.

Tertiary Revolution in the Topography of the Pacific Coast. By J. S. DILLER. U. S. Geol. Survey, 14th Ann. Report, pp. 397–434.

An ancient peneplain is traced about the northern portion of the Sacramento valley and the western slope of the Sierra Nevada. It was once covered with residual material that gave rise to the earlier auriferous gravels.

The topographic revolution consisted in the development out of such lowland conditions of the conspicuous mountain ranges of today. The northern end of the Sierra Nevada was raised at least 4000 feet, and a fault was formed along the eastern escarpment. As the uplift progressed the rejuvenated streams at first accumulated the auriferous gravels and finally, displaced by volcanic flows, cut deep canyons down the western slope of the range.

The Kame-Moraine at Rochester, New York. By H. L. FAIRCHILD. Am. Geologist, Vol. XVI., July 1895.

The "Pinnacle" hills at Rochester, New York, with their complex and puzzling structure, are explained as a frontal moraine, with a pre-

ponderance of water-laid drift. The eastern half of the range is a ridge-like series of sand and gravel knolls, with considerable till, the latter partially as a capping. The western half of the range is a typical kame-area. The topography of the whole range is decidedly morainic. With a trend of about 15° south of west the whole range forms part of a curving moraine which beyond the Genesee River swings north of west toward Albion. A critical fact is the discovery of a late system of glacial striæ, over all the vicinity, at right angles to the range, or radial to the arc of the curving moraine. These features are shown by a sketch map.

Certain structural features, as the occurrence of extensive deposits of horizontal fine sands and silts, sometimes occupying the whole breadth of the range, are explained by deposition in the water of the glacal Lake Warren, which is believed to have laved the retreating ice-front throughout western New York.

The paper enumerates other kame-areas in the region, two of which are of much greater bulk and area than the Pinnacle hills.

Essential Properties of Building Stones. By H. FOSTER BAIN. Reprint Monthly Review Iowa Weather and Crop Service, 22 pp., Des Moines, 1895.

This essay presents in convenient form a summary of information on the subject. It is intended for popular distribution so citations to original authorities are omitted. The essential properties of a stone in relation to its use for building purposes are considered to be (1) Strength, (2) Durability, (3) Color, (4) Workability, (5) Availability. The first two topics are treated more fully as being of the greater importance.

Recconnaisance of the Gold Fields of the Southern Appalachians. By GEO. F. BECKER, Ann. Rep. U. S. Geol. Surv. 1894–5. Part III.

This report is based on field work done in 1894, but the work of previous observers in the same area is of course taken into consideration. It also includes a digest of the literature dealing with the gold deposits of Nova Scotia and other northerly auriferous districts, the purpose being to present in a single paper the most noteworthy facts of gold occurrence on the entire eastern side of the continent. The total pro-

duction of the Southern Appalachians to the end of 1894 was over $45,000,000, which has come chiefly from the Carolinas and Georgia. The deposits are distributed along belts which are parallel to the general trend of the Appalachians. The primary deposits are real veins or secondary impregnations, not beds as has sometimes been maintained, and the ores are similar to those in most gold-bearing regions. They are quartzose masses with very subordinate admixtures of carbonates in which pyrite is always present while chalcopyrite is common and galena, mispickel and zincblende are not rare. The veins commonly follow the schistosity of the pre-Cambrian schists and include fragments of the wall rock. The impregnations occur chiefly in Algonkian fragmental volcanics similar to those of the South Mountain of Pennsylvania. The deposition of ore is associated with intrusions believed to belong to the same Algonkian epoch, but it is more recent than the mountain building era during which the schistose structure was developed. The veins were opened by normal faulting and no indications of the replacement of wall rock by quartz were detected. The term "stringer lead" is proposed for a group of small auriferous veinlets such as usually constitutes the basis of economical operations in the South and is very common in California and Australia. The impregnations, that of the Haile mine for example, are similar to the Norwegian Fahlbands. The ores of the Maritime Provinces appear to be of the same age as those of the South and to resemble them closely. The placers of the southern Appalachians are in part stream gravels and in part consist of quartz-bearing rock, which is in place but entirely decomposed. The term "saprolite" is used to denote such untransported but thoroughly rotten rock. In the South the saprolite forms a blanket which is generally from 30 to 100 feet in thickness. About half of the report deals with the deposits systematically and the remainder consists of descriptive notes on the different areas.

Index to Volume III.

ABSTRACTS:

The Honeycombed Limestone of Lake Huron. Robert Bell, by D. P. N. 869
Critical Periods of the Earth's History. J. L. Le Conte, by D. P. N. - 870
Tepee Buttes, G. K. Gilbert and F. P. Gulliver, by D. P. N. - 870

ABSTRACTS, AUTHORS:

Reconnaissance of the Gold Fields of the Southern Appalachians. Geo. F. Becker - - - - - - - - - 989
The Stone Industry in 1894. Wm. C. Day - - - - - 985
The Rocks of the Sierra Nevada. H. W. Turner. - - - - 985
Results of Stream Measurements. F. H. Newell. - - - 986
Report on the Coosa Coal Field with Sections. A. M. Gibson. - 986
The Structure of Monument Mountain in Great Barrington, Massachusetts. T. Nelson Dale. - - - - - - - 987
On the Structure of the Ridge between the Taconic and Green Mountain Ranges in Vermont. T. Nelson Dale. - - - - 987
Tertiary Revolution in the Topography of the Pacific Coast. J. S. Diller. 988
Notes on the Stratigraphy of the Cambro-Silurian Rocks of Eastern Manitoba. D. B. Dowling. - - - - - - - 988
Iowa Geological Survey, Vol. IV. Samuel Calvin. - - - 977
Allamakee County. Samuel Calvin. - - - - - - 978
Linn County. Wm. Harmon Norton. - - - - - 979
Van Buren County. C. H. Gordon. - - - - - - 979
Keokuk and Mahaska Counties. H. Foster Bain. - - 979
Montgomery County. E. H. Lonsdale. - - - - 980
Essential Properties of Building Stones. H. Foster Bain. - - 989
Stratigraphy of Kansas Coal Measures; Divisions of Kansas Coal Measures; The Coal Fields of Kansas. Erasmus Haworth. - 983
Crystalline Limestones, Ophicalcites and Associated Schists of the Eastern Adirondacks. J. F. Kemp. - - - - - - - 983
The Erosive Action of Ice. G. E. Culver. - - - - - 982
Annual Report of the State Geologist of New Jersey, for 1894. Rollin D. Salisbury. - - - - - - - - - 984
U. S. Geological Atlas, Folio 11, Jackson, Cal. - - - 969
12, Estillville, Ky., Va., and Tenn. - - - - - - 970
13, Fredericksburg, Va., Md. - - - - - - 972
14, Staunton, Va., and W. Va. - - - - - - 973
15, Lassen Peak, Cal. - - - - - - - - - 974
17, Marysville, Cal. - - - - - - - - - 976
How Old is the Mississippi. Francis M. Fultz. - - - - 981

ABSTRACTS, AUTHORS:
Glacial Markings in Southeastern Iowa. Francis M. Fultz. - 981
The Kame-Moraine at Rochester, New York. H. L. Fairchild. - 988
The Rocks of the Sierra Nevada. H. W. Turner. - - - 985
Absarokite-Shoshonite-Banakite Series. Joseph P. Iddings. - - - 935
Ægina and Methana, a Petrographic Sketch of. Henry S. Washington. - 21–138
Alaska, Distribution of Gold Deposits in. Geo. F. Becker - - - 960
Alberta, Notes on Glacial Deposits of Southwestern. Geo. M. Dawson - 507
Algonkian Rocks of the Grand Canyon Region. C. D. Walcott. - - 312
Adirondacks, Crystalline Limestone, Ophicalcites and Associated Schists of. J. F. Kemp (abstract.) - - - - - - - - 983
American Glacial Deposits, the Classification of. T. C. Chamberlin. - 270
Anderson, T. M. Some Cretaceous Beds of the Rogue River Valley, Oregon. 455
Aneroid Barometer, Use of in Geological Survey. C. W. Rolfe. - - 128
Anthracite, Col., U. S. Geologic Atlas, Folio 11 (abstract). - - - 969
Ashley, George H. Studies in the Neocene of California. - - - 434
Bain, H. F. Origin of Certain Features in Coal Basins. - - - 646
Review: Preliminary Report on the Geology of South Dakota. J. E. Todd. - - - - - - - - - 114
Geology of Keokuk County (abstract). - - - - - - 979
Essential Properties of Building Stones (abstract). - - - 989
Baird Glacier. Photo-Topographical Method of Surveying Applied to. Otto J. Klotz. - - - - - - - - - 512
Basic Massive Rocks of the Lake Superior Region. W. S. Bayley. - 1
Bayley, W. S. Basic Massive Rocks of the Lake Superior Region. - - 1
Baur, G. Reviews: Pithecanthropus-erectus, by Eug. Dubois. - - 237
The Fins of Icthyosaurus. - - - - - - - 238
Banakite-Absarokite-Shoshonite Series. Joseph P. Iddings. - - 935
Becker, Geo. F. Distribution of Gold Deposits in Alaska. - - - 960
Reconnaissance of the Gold Fields of the Southern Appalachians (abstract). - - - - - - - - - 989
Bell, Robert. A Great Glacial River in Canada. - - - - - 590
Building Stones, Essential Properties of. H. Foster Bain (abstract). - 989
Calvin, Samuel. Iowa Geological Survey (abstract). - - - 969
California, Mesozoic Changes in Faunal Geography of. James Perrin Smith. 369
California Coast Ranges, the Stratigraphy of. H. W. Fairbanks - - 415
California, Studies in the Neocene of. George H. Ashley. - - 434
Cambro-Silurian Question in Missouri and Arkansas. C. R. Keyes. - - 519
Cambro-Silurian Rocks of Eastern Manitoba. D. B. Dowling (abstract). - 988
Carboniferous of Illinois. New Species of Petalodus from. O. P. Hay. - 561
Case, E. C. Experiments in Ice Motion. - - - - - - 918
Chamberlin, T. C. Editorials. - 98, 219, 220, 341, 342, 496, 583, 963, 964, 965
Glacial Studies in Greenland. - - - 61, 198, 469, 565, 668, 833
The Classification of American Glacial Deposits. - - - - 270
Reviews: Air-Breathing Animals of the Palæozoic of Canada up to 1894. Sir William Dawson. - - - - - - - 588

Chamberlin, T. C. Reviews: Missouri Geological Survey, Vols. IV, V, VI, and VII. C. R. Keyes and assistants. - - - - - - 591
Geological and Natural History Survey of Minnesota. Vol. III, Pt. I. N. H. Winchell and assistants. - - - - - - 595
Circum-Insular Palæozoic Fauna. S. Weller. - - - - - - 903
Clements, J. Morgan. The Volcanics of the Michigamme District of Michigan. 801
Cliffs and Exotic Blocks of North Switzerland. E. C. Quereau. - - 723
Clinton Conglomerate and Wave-Marks in Ohio and Kentucky. Aug. F. Foerste. - - - - - - - - - 50, 138
Coal Basins, Origin of Certain Features of. H. F. Bain. - - - 646
Coleman, A. P. Glacial and Inter-Glacial Deposits near Toronto. - - 622
Coosa Coal Field, Report on. A. M. Gibson (abstract). - - - 986
Cretaceous Beds of Rogue River Valley, Oregon. F. M. Anderson. - - 455
Cretaceous Time, Sedimentary Measurement of. G. K. Gilbert. - - 121
Culver, G. E. The Erosive Action of Ice (abstract). - - - - 982
Dale, T. Nelson. The Structure of Monument Mountain in Great Barrington, Mass. (abstract). - - - - - - - 987
On the Structure of the Ridge between the Taconic and Green Mountain Ranges in Vermont (abstract). - - - - - 987
Dana, James D., as a Teacher of Geology. Oliver C. Farrington. - 335
As a Geologist. H. S. Williams. - - - - - 601
Dawson, Geo. M. Notes on the Glacial Deposits of S. W. Alberta. - 507
Day, Wm. C. The Stone Industry in 1894 (abstract). - - - 985
Débris, Influence of on the Flow of Glaciers. Israel C. Russell. - - 823
Diller, J. S. Tertiary Revolution in the Topography of the Pacific Coast. (abstract). - - - - - - - - - 988
Dowling, D. B. Notes on the Stratigraphy of the Cambro-Silurian Rocks of Eastern Manitoba (abstract). - - - - - 988
EDITORIALS:
Winter Meeting of Geol. Soc. of America. T. C. C. - - - 98
Alpine Excursion of International Congress of Geologists. T. C. C. 219
Conferring of Bigsby Medal. T. C. C. - - - - - - 220
Prof. James D. Dana. T. C. C. - - - - - 341
Prof. Henry B. Nason. T. C. C. - - - - - 342
California Number of Journal. T. C. C. - - - - 496
Polar Expeditions. T. C. C. - - - - - - 583
Summer Meeting of the Geological Society of America. J. P. I. - 706
Results of Mr. Peary's Polar Explorations. R. D. S. - - - 844
The North Greenland Expedition of 1895. R. D. S. - - 847
The Jackson-Harmsworth Polar Expedition. R. D. S. - - - 848
The Death of Dr. Geo. M. Dawson. T. C. C. - - - 963
Experiment in Ice Motion, by Mr. Case. T. C. C. - - - 963
Investigations on Plasticity of Ice, by Dr. Mügge. T. C. C. - 965
Erosion, Lake Basins Created by. G. K. Gilbert. - - - - 47
European Glacial Deposits, the Classification of. James Geikie. - - 241
Expedition of 1895, the Greenland. Rollin D. Salisbury. - - - 875

Experiments in Ice Motion. E. C. Case. - - - - - 918
Fairbanks, H. W. The Stratigraphy of the California Coast Ranges. - 415
Farrington, Oliver C. James D. Dana as a Teacher of Geology (Studies for Students). - - - - - - - - - 335
Fauna, A Circum-Insular Palæozoic. S. Weller. - - - - 903
Foerste, Aug. F. Clinton Conglomerates and Wave-Marks in Ohio and Kentucky. - - - - - - - - - 50, 169
Fultz, Francis M. How Old is the Mississippi? (abstract). - - - 981
Glacial Striæ in Southeastern Iowa (abstract). - - - 981
Geologic Atlas of U. S., Folio 11, Jackson, Cal. (abstract). - - - 969
Folio 12, Estillville, Ky., Va. and Tenn. (abstract). - - - 970
Folio 13, Fredericksburg, Va., Md. (abstract). - - - - 972
Folio 14, Staunton, Va. and W. Va. (abstract). - - - 973
Folio 15, Lassen Peak, Cal. (abstract). - - - - - 974
Folio 17, Marysville, Cal. (abstract). - - - - - 976
Geologic Study of the Migration of Marine Invertebrates. James Perrin Smith. 481
Geological Survey, Use of Aneroid Barometer in. C. W. Rolfe. - - 128
Geology, James D. Dana as a Teacher of. Oliver C. Farrington. - - 335
Geologist, James D. Dana as a. H. S. Williams. - - - - 601
Gibson, A. M. Report on the Coosa Coal Field with Sections (abstract). - 986
Geikie, James. The Classification of European Glacial Deposits. - - 241
Gilbert, G. K. Lake Basins Created by Erosion. - - - - 47
Sedimentary Measurement of Cretaceous Time. - - - - 121
New Light on Isostasy. - - - - - - 331
Glacial Deposits, Classification of European. James Geikie. - - - 241
Glacial Deposits, Classification of American. T. C. Chamberlin. - - 270
Glacial Lake, An Extinct. R. D. Salisbury and H. B. Kümmel. - - 533
Glacial Studies in Greenland. T. C. Chamberlin. - 61, 198, 469, 565, 668, 833
Glacial Deposits of S. W. Alberta, Notes on. Geo. M. Dawson. - - 507
Glaciers, Variations of. Harry Fielding Reid. - - - - 278
Glaciers, Influence of Débris on the Flow of. Israel C. Russell. - - 823
Gold Deposits in Alaska, Distribution of. Geo. F. Becker. - - 960
Gold Fields of the Southern Appalachians, Reconnaissance of. Geo. F. Becker (abstract). - - - - - - - - - 989
Gordon, C. H. Stratigraphy of the Saint Louis and Warsaw Formations in Southeastern Iowa. - - - - - - - - 289
Geology of Van Buren County, Iowa (abstract). - - - 979
Summary: Post-Glacial Submergence in the Region of the Great Lakes. 349
Grand Canyon of the Colorado, Algonkian Rocks of. C. D. Walcott. - - 312
Greenland, Glacial Studies in. T. C. Chamberlin. - 61, 198, 469, 565, 668, 833
Greenland Expedition of 1895. Rollin D. Salisbury. - - - - 875
Grimsley, G. Perry. Reviews: Ueber Archaeische Ergussgesteine aus Småland. Otto Nordenskjöld. - - - - - - - - 498
Elements of Mineralogy, Crystallography and Blowpipe Analysis from a Practical Standpoint. Albert J. Moses and Chas. L. Parsons. - 585
Haworth, Erasmus. Kansas Coal Measures and Kansas Coal Fields (abstract). 983

Hay, O. P. Description of a new Species of Petalodus from the Carboniferous of Illinois. - - - - - - - - - - 561
Hopkins, T. C. Review: The Mineral Industry, its Statistics, Technology and Trade in the United States and other Countries. R. P. Rothwell. 868
Ice, Erosive Action of. G. E. Culver (abstract). - - - - - 982
Ice Motion, Experiments in. E. C. Case. - - - - - - 918
Iddings, Joseph P. Editorial: Summer Meeting of the Geological Society of America. - - - - - - - - - - 706
Absarokite — Shoshonite — Banakite Series - - - - - 935
Reviews: On Banded Structure of some Tertiary Gabbros of the Isle of Skye, by Archibald Geikie and J. J. H. Teall. - - - 112
Notes on some Eruptive Rocks from Gallatin, Jefferson and Madison Counties, Montana, by Geo. P. Merrill. - - - - - 850
Highwood Mountains of Montana, by Walter H. Weed. - - 851
The Laccolitic Mountain Groups of Colorado, Utah and Montana, by Whitman Cross. - - - - - - - - 853
Petrology for Students, by Alfred Harker - - - - 856
Igneous Rocks of the Sierra Nevada, Age and Succession of. H. W. Turner. 385
Inter-Glacial Wood from Muir Glacier, Alaska. F. H. Knowlton. - 527
Inter-Glacial Deposits near Toronto. A. P. Coleman. - - - - 622
Iowa Geological Survey. - - - - - - - - 977
Geology of Allamakee County. Samuel Calvin. - - - 978
Geology of Linn County. Wm. Harmon Norton. - - - 979
Geology of Van Buren County. C. H. Gordon. - - - 979
Geology of Keokuk and Mahaska Counties. H. Foster Bain. - 979
Geology of Montgomery County. E. H. Lonsdale. - - - 980
Iowa, Glacial Striæ in Southeastern. Francis M. Fultz (abstract). - - 981
Isostasy, New Light on. G. K. Gilbert. - - - - - - 331
Jackson, Cal., U. S. Geologic Atlas, Folio 11 (abstract). - - - 969
Kansas, Classification of the Upper Palæozoic Rocks of Central. C. S. Prosser. 682–764
Kansas, Coal Fields and Coal Measures. Erasmus Haworth (abstract). - 983
Kemp, J. F. Crystalline Limestones Ophicalcites and Associated Schists of the Eastern Adirondacks (abstract). - - - - - - 983
Keyes, C. R. The Cambro-Silurian Question in Missouri and Arkansas. - 519
Klotz, Otto J. Experimental Application of the Photo-Topographical Method of Surveying to the Baird Glacier, Alaska. - - - - 512
Knowlton, F. H. Notes on the Examination of a Collection of Inter-Glacial Wood from Muir Glacier, Alaska. - - - - - - 527
Kümmel, H. B. Reviews: Geological Map of Alabama. - - - - 117
Some Coal Measure Sections near Peytona, West Virginia, by Benjamin Lyman Smith. - - - - - - - - - - 117
Reconstruction of the Antillean Continent, by J. W. Spencer. - 364
Meteorology, Weather and Method of Forecasting. Thomas Russell. 587
and R. D. Salisbury. Lake Passaic, an Extinct Glacial Lake. - - 533
Lake Basins Created by Erosion. G. K. Gilbert. - - - - - 47
Lake Superior Region — Bassic Massive Rocks of. W. S. Bayley. - - 1

Lake Passaic, an Extinct Glacial Lake. R. D. Salisbury and H. B. Kümmel. 533
Lassen Peak, Cal., U. S. Geologic Atlas Folio 15 (abstract). - - - 974
Leverett, Frank. Pre-Glacial Valleys of the Mississippi and Tributaries - 740
Lonsdale, E. H. Geology of Montgomery County, Iowa (abstract). - - 980
Marysville, California, U. S. Geologic Atlas Folio 17 (abstract). - - 976
Mathews, E. B. Review: Ueber die Holocrystalline Macrovariolitische Gesteine, by K. V. Crustchoff. - - - - - 108
Merriam, J. C. Review: Elementary Palæontology for Geological Students. Henry Woods. - - - - - - - - - 594
Mesozoic Changes in the Faunal Geography of California. James Perrin Smith. 369
Michigamme District of Michigan, the Volcanics of. J. Morgan Clements. 801
Mississippi and Tributaries, Pre-Glacial Valleys of. Frank Leverett. - 740
Missouri and Arkansas, the Cambro-Silurian Question in. C. R. Keyes. - 519
Mississippi, How Old is the? Francis M. Fultz (abstract). - - 981
Monument Mountain in Great Barrington, Mass., Structure of. T. Nelson Dale (abstract). - - - - - - - - - 987
Muir Glacier, Examination of Inter-Glacial Wood from. F. H. Knowlton. 527
Neocene of California, Studies in—George H. Ashley. - - - 434
Newell, F. H. Results of Stream Measurements (abstract). - - 986
New Jersey, Report of State Geologist for 1894. R. D. Salisbury (abstract). 984
New Light on Isostasy. G. K. Gilbert. - - - - - 331
Norton, Wm. Harmon. Geology of Linn County, Iowa (abstract). - 979
Ohio and Kentucky, Clinton Conglomerate and Wave Marks in—August F. Foerste. - - - - - - - - 50–169
Oregon, Some Cretaceous Beds of Rogue River Valley. F. M. Anderson. 455
Origin of Certain Features in Coal Basins. H. F. Bain. - - 646
Palæozoic Rocks of Central Kansas. C. S. Prosser. - - - 682–764
Penrose, R. A. F., Jr., and Joseph P. Iddings. Reviews: Penokee Iron Bearing Series of Michigan and Wisconsin. R. D. Irving and C. R. Van Hise. - - - - - - - - - 221
Geological Survey of Ohio, Vol. VII. Edward Orton. - - - 353
Petalodus, New Species of, from Carboniferous of Illinois. O. P. Hay. - 561
Petrographical Sketch of Ægina and Methana. H. S. Washington - 21–138
Photo-Topographical Method of Surveying, Applied to Baird Glacier, Alaska. Otto J. Klotz. - - - - - - - - 512
Pre-Cambrian Literature, Summary of North American—C. R. Van Hise. 227–709
Pre-Glacial Valleys of the Mississippi and Tributaries. Frank Leverett. - 740
Pre-Glacial Gravels on the Quartzite Range near Baraboo, Wisconsin. R. D. Salisbury. - - - - - - - - - 655
Prosser, C. S. The Classification of the Upper Palæozoic Rocks of Central Kansas. - - - - - - - - 682–764
Quartzite Range near Baraboo. Wisconsin, Pre-Glacial Gravels on—R. D. Salisbury. - - - - - - - - - 655
Quereau, E. C. The Cliffs and Exotic Blocks of North Switzerland. - 723
Review: Elements de Paleontologie. Felix Bernard. - - - 368
Reid, Harry Fielding. The Variations of Glaciers. - - 278

REVIEWS:

Geology of the Coastal Plain of Alabama, E. A. Smith, by R. D. Salisbury. - - - - - - - - - - - 101
Ueber Holocrystalline Macrovariolitische Gesteine, K. V. Crustchoff, by E. B. Mathews. - - - - - - - 108
On Banded Structure of Some Tertiary Gabbros of the Isle of Skye, Archibald Geike and J. J. H. Teall, by J. P. Iddings. - - 112
Preliminary Report on the Geology of South Dakota, J. E. Todd, by H. F. Bain. - - - - - - - - - - 114
The Geomorphogeny of the Coast of Northern California, A. C. Lawson, by A. R. Whitson. - - - - - - - 116
Geological Map of Alabama, by H. B. Kümmel. - - - - 117
Some Coal Measure Sections near Peytona, West Virginia, Benjamin Smith Lyman, by H. B. Kümmel. - - - - - 117
Penokee Iron-Bearing Series of Michigan and Wisconsin, R. D. Irving and C. R. Van Hise, by R. A. F. Penrose, Jr. and Joseph P. Iddings. 221
Pithecanthropus-erectus, Eugene Dubois, by G. Baur. - - - 237
The Fins of Icthyosaurus, by G. Baur. - - - - - 238
Die Entstehung der Blei, Zink und Eisenertzlogerstaten in Oberschliesen, H. Höfer, by Arthur Winslow. - - - - - - 344
Fragments of Earth Lore, James Geikie, by R. D. Salisbury. - - 348
Post-Glacial Submergence in the Region of the Great Lakes (Summary), C. H. Gordon. - - - - - - - - 349
Geological Survey of Ohio, Vol. VII., Edward Orton, by R. A. F. Penrose, Jr. and E. C. Quereau. - - - - - - - 353
Report on Surface Geology of New Jersey, R. D. Salisbury, by I. C. Russell. - - - - - - - - - - 358
Reconstruction of the Antillean Continent, J. W. Spencer, by H. B. Kümmel. - - - - - - - - - 364
Elements de Paleontologie, Felix Bernard, by E. C. Quereau. - 368
Ueber Archaeische Ergussgesteine aus Småland, Otto Nordenskjöld, by G. Perry Grimsley. - - - - - - - - - 498
Elements of Mineralogy, Crystallography and Blowpipe Analysis from a Practical Standpoint, Albert J. Moses and Charles L. Parsons, by G. Perry Grimsley. - - - - - - - - - 585
Memoir of Sir Andrew Crombie Ramsay, Archibald Geikie, by R. D. Salisbury. - - - - - - - - - - 586
Meteorology, Weather and Method of Forecasting, Description of Meteorological Instruments and River Flood Predictions in the United States, Thomas Russell, by H. B. Kümmel. - - - - - 587
Air Breathing Animals of the Palæozoic in Canada up to 1894, Sir William Dawson, by T. C. Chamberlin. - - - - - 588
Om Klitternes Vandring, J. K. V. Steenstrup, by J. A. Udden. - - 589
Missouri Geological Survey, Vols. IV., V., VI., VII., C. R. Keyes and Assistants, by T. C. Chamberlin. - - - - - - 591
Highwood Mountains of Montana, Walter H. Weed, by J. P. Iddings. 851

REVIEWS:
Elementary Palæontology for Geological Students, Henry Woods, by J. C. Merriam. - - - - - - - - - 594
Geological and Natural History Survey of Minnesota, Vol. III., Part I., N. H. Winchell and Assistants, by T. C. Chamberlin. - - 595
Notes on Some Eruptive Rocks from Gallatin, Jefferson and Madison Counties, Montana, George P. Merrill, by J. P. Iddings. - - 850
The Laccolitic Mountain Groups of Colorado, Utah and Montana, Whitman Cross, by J. P. Iddings. - - - - - - 853
Petrology for Students, Alfred Harker, by J. P. Iddings. - - 856
Boletin de la Comision Geologica de Mexico, No. I.: Fauna Fossil de la Sierra de Catorce, San Louis Potosi, Antonio Del Castillo and Jose G. Anguilera, by T. W. Stanton. - - - - - - - 858
The Phylogeny of an Acquired Character, Alpheus Hyatt, by S. Weller. 861
The Protolepus Fauna, G. F. Mathew, by S. Weller. - - 866
Republication of Descriptions of Fossils from the Hall Collection, R. P. Whitfield, by S. Weller. - - - - - - - 867
The Mineral Industry, Its Statistics, Technology and Trade in the United States and other Countries. Vol. III. R. P. Rothwell. By T. C. Hopkins. - - - - - - - - - 868
The Mollusca and Crustacea of the Miocene of New Jersey. S. Weller. 968
Rolfe, C. W. Use of Aneroid Barometer in Geological Survey. - - 358
Russell, I. C. The Influence of Débris on the Flow of Glaciers. - - 823
Review: Report on the Surface Geology of New Jersey. R. D. Salisbury. - - - - - - - - - - 358
Saint Louis and Warsaw Formations of Southeastern Iowa, Stratigraphy of. C. H. Gordon. - - - - - - - - 289
Salisbury, Rollin D. Agencies which Transport Material on the Earth's Surface. - - - - - - - - - - - 70
Pre-Glacial Gravels on the Quartzite Range near Baraboo, Wis. - 655
The Greenland Expedition of 1895. - - - - - - 875
Annual Report of the State Geologist of New Jersey for 1894 (abstract). 987
Reviews: Geology of the Coastal Plain of Alabama. E. A. Smith. 101
Fragments of Earth Lore. James Geikie. - - - - 586
Memoir of Sir Andrew Crombie Ramsay. Archibald Geikie. - 348
Editorials: Results of Mr. Peary's Polar Expedition. - - - 844
The North Greenland Expedition of 1895. - - - - 847
The Jackson-Harmsworth Polar Expedition. - - - - 848
and H. B. Kümmel. Lake Passaic, an Extinct Glacial Lake. - - 533
Sedimentary Measurement of Cretaceous Time. G. K. Gilbert. - - 121
Shoshonite-Banakite-Absarokite Series. Joseph P. Iddings. - - 935
Sierra Nevada, Age and Succession of Igneous Rocks of. W. H. Turner. - 385
Smith, James Perrin. Mesozoic Changes in the Faunal Geography of California. - - - - - - - - - - 369
Studies for Students: Geologic Study of the Migrations of Marine Invertebrates. - - - - - - - - - 481

Spencer, J. W. Note on Mr. Kümmel's Review of "Reconstruction of Antillean Continent." - - - - - - - - - - 497
Stanton, T. W. Review: Boletin de la Comision Geologica de Mexico, No. I.: Fauna Fossil de la Sierra de Catorce, San Louis Potosi. Antonio Del Castillo and Jose G. Anguilera. - - - - - - 858
Staunton, Va., U. S. Geologic Atlas, Folio 14 (abstract). - - - - 973
Stone Industry in 1894. Wm. C. Day (abstract). - - - - - 985
Stratigraphy of the California Coast Ranges. H. W. Fairbanks. - - 415
Stratigraphy of the Saint Louis and Warsaw Formations of Southeastern Iowa. C. H. Gordon. - - - - - - - - - - 289
Stream Measurements, Results of. F. H. Newell (abstract). - - - 986
STUDIES FOR STUDENTS:
Agencies which Transport Material on the Earth's Surface. Rollin D. Salisbury. - - - - - - - - - - 70
James D. Dana as a Teacher of Geology. Oliver J. Farrington. - 335
Geologic Study of the Migrations of Marine Invertebrates. James Perrin Smith. - - - - - - - - - 481
Switzerland, Cliffs and Exotic Blocks of North. E. C. Quereau. - - 723
Taconic and Green Mountain Ranges in Vermont, Structure of the Ridge between. T. Nelson Dale (abstract). - - - - - 987
Tertiary Revolution in the Topography of the Pacific Coast. J. S. Diller (abstract). - - - - - - - - - - 988
Toronto, Glacial and Inter-Glacial Deposits near. A. P. Coleman. - 622
Turner, W. H. The Age and Succession of the Igneous Rocks of the Sierra Nevada. - - - - - - - - - - 385
The Rocks of the Sierra Nevada (abstract). - - - - - 985
Udden, J. A. Review: Om Klitternes vandring. K. J. V. Steenstrup. - 589
Van Hise, C. R. Summary of Current Pre-Cambrian North American Literature. - - - - - - - - - - 227, 709
Variations of Glaciers. Harry Fielding Reid. - - - - - - 278
Volcanics of the Michigamme District of Michigan. J. Morgan Clements. - 801
Walcott, C. D. Algonkian Rocks of the Grand Canyon of the Colorado. - 312
Washington, H. S. A Petrographical Sketch of Ægina and Methana. - 21, 138
Weller, S. A Circum-Insular Palæozoic Fauna. - - - - - 903
Reviews: The Phylogeny of an Acquired Character. Alpheus Hyatt. 861
The Protolenus Fauna. G. F. Matthews. - - - - - 866
Republication of Descriptions of Fossils from the Hall Collection. R. P. Whitfield. - - - - - - - - - - 867
Mollusca and Crustacea of the Miocene of New Jersey. R. P. Whitfield. 968
Whitson, A. R. Review: The Geomorphogeny of the Coast of Northern California. A. C. Lawson. - - - - - - - 116
Williams, H. S. James D. Dana as a Geologist. - - - - - 601
Winslow, Arthur. Review: Die Entstehung der Blei, Zink und Eisenerzlogerstätten in Ober Schliesen. H. Höfer. - - - 344